Engineering

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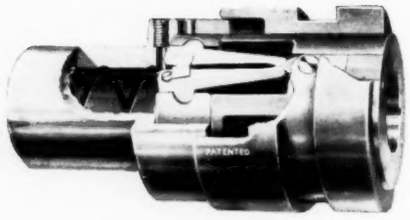

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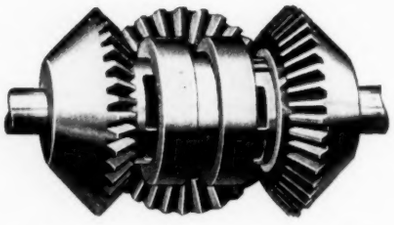

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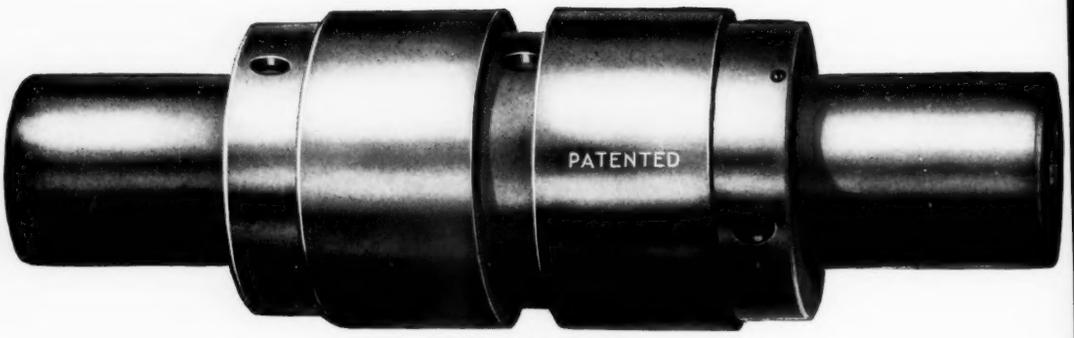

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Contents for April, 1931

VOLUME 2 . . . NUMBER 4

Copyright, 1931, by the McGraw-Hill Publishing Company, Inc.

It All Comes Back to the Product 145
Editorial

Engineering the Rotolactor 146
KRAEMER LUKS

Intricate Shapes in Aluminum Bronze 151
A Picture Page

Roller Chain Drives in Theory and Practice 152
G. M. BARTLETT

Compactness and Light Weight Govern Motorcycle Design . . . 155
W. S. HARLEY

Electric Motor Selection 158

Lacquers for Stamped and Formed Parts 162
LEO ROON

Why Metals Fail 164
H. F. MOORE

Welded Construction Applied to Special Machinery 167
D. V. WATERS

Silvery Platings Where the Color Counts 171
HAROLD WHITEHEAD

A Platform for American Business 145
A Supplement

BOOKS FOR ENGINEERS 150
COMMENT AND SUGGESTION . . 172
EDITORIALS 145, 176
WHAT'S GOING ON 178
NEW MATERIALS AND PARTS . . 184
REFERENCE BOOK SHEETS 191

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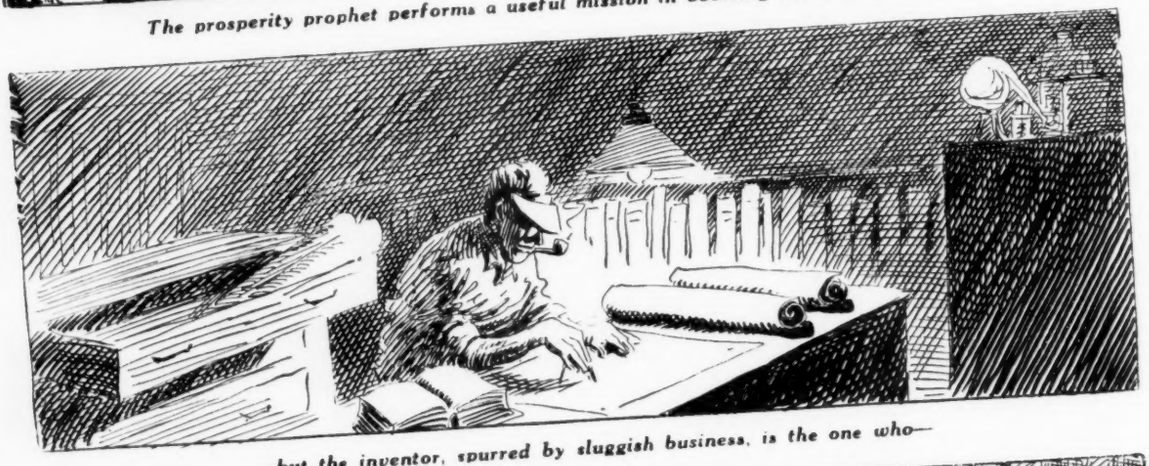

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—and the May number of Product Engineering will tell about the design of some of the outstanding machines which are right now hanging up sales records because of the work of their product engineers . . . . . .

DON'T MISS OUT ON THE MAY ISSUE

• PRODUCT ENGINEERING •

PRODUCT ENGINEERING

A McGraw-Hill Publication Volume Two, Number 4

APRIL
1931

IT ALL COMES BACK TO THE PRODUCT

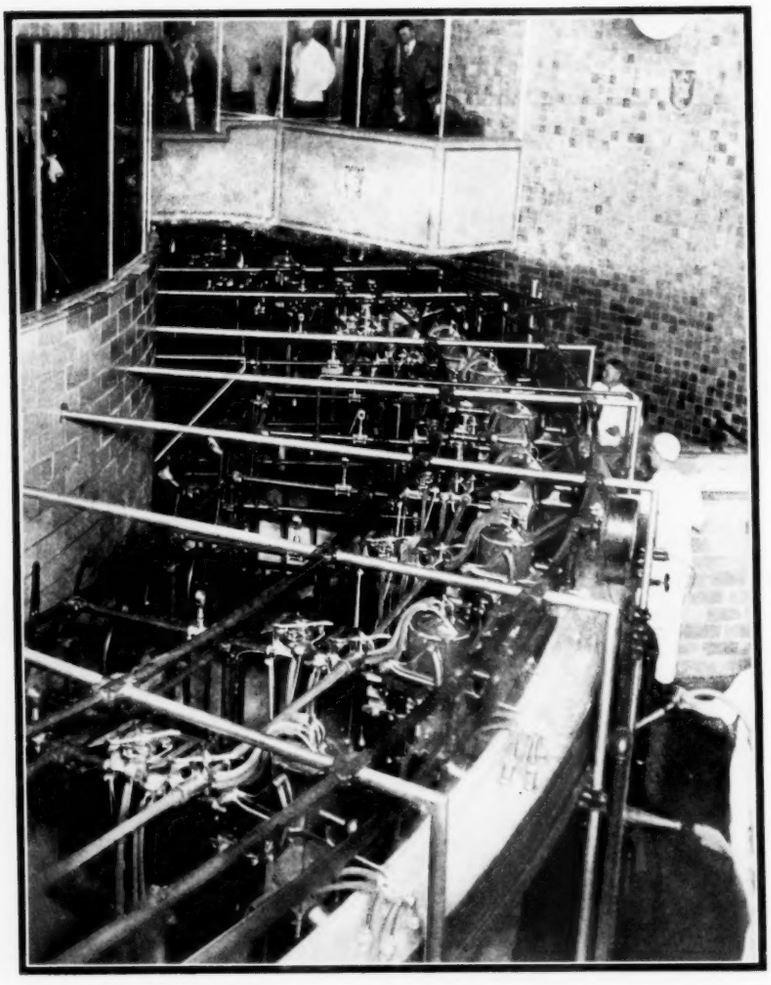
PRODUCT engineers and designers everywhere will find much to provoke thought, and much to stimulate added effort, in the Platform for American Business published as a supplement to this number of *Product Engineering*. This platform offers not only a carefully considered plan for the betterment of business in general, but a check sheet by which each individual company can study its own accomplishments and its potentialities. The editors will welcome comments on the timeliness of the plan and on its general soundness.

Analyze particularly the first major section of the check sheet, the part dealing with long-term planning. There is excellent advice on sales control, on production modernization, on financial policies, but everything hinges on having the right product to begin with. Right from the customer's standpoint, right from the standpoint of holding present markets, right from the standpoint of capturing new markets.

What is the point of modernizing equipment to manufacture a product that is losing public favor, or of attempting to stabilize financing when your product will not sell? Research and product development, market studies and sales planning come first, and in them lies the responsibility and the opportunity of the product engineer.

When each company has its house in order and can look forward with reasonable security to profitable operation it can then do its part in advancing industrial or trade co-ordination, make its contribution to national prosperity, and even lift its voice in behalf of the maintenance of world business. But, after all, it all comes back to the product. Unless that is right little progress is possible.

SO convinced of the soundness of this principle are the editors of *Product Engineering* that the May number will be devoted largely to accounts of outstanding sales successes built on able product engineering. The examples were chosen from among products that showed appreciable increases in sales during 1930, one of the dullest years in the experience of men now living. Success against such odds speaks volumes for the work of the product engineer and should stimulate him to even greater endeavors.



The designer of the machine that washes, dries and milks 240 cows an hour at the Walker-Gordon Laboratory tells how mechanization was made to fit the peculiarities of an animal's behavior, also how perfect sanitation, the major problem of milk production, was assured by the elimination of human contact with the milk

By KRAEMER LUKS

Chief Engineer, Walker-Gordon Laboratory Company, Inc.

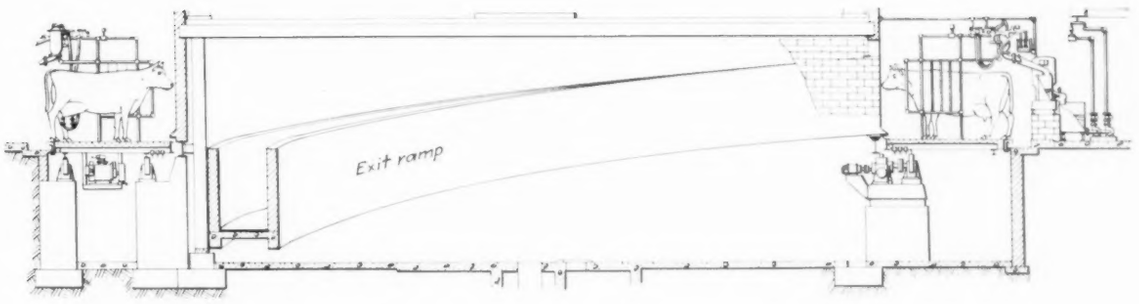
Engineering the Rotolactor

MILKING APPARATUS that would turn out a milked cow every fifteen seconds: that would wash, dry, and milk 240 cows an hour: that would complete 5,040 milkings in twenty-one hours, and do this continuously for seven days a week with only three hours a day to be allowed for repairs and replacements—this was the problem that confronted the designers of the Rotolactor. Today, after four years of research and development, this machine is in daily operation, milking more than 800 cows three times a day with more cows being added as rapidly as they can be trained into the system.

One unique characteristic distinguishes this particular machine from all other continuous production machines. This is the first time that the idea of continuous production has been applied to a process in which the living animal figures so prominently. In fact the behavior of the animal was the core around which the machine had to be designed, since she herself, no matter how imperfect, admitted of no changes except through the slow process of evolution, for which there was no time to wait. The first thing to do was to find out a great many things about the characteristics of a cow; her temperature, pressure, likes, dislikes, fears, and other psychological reactions.

The next step was to determine experimentally whether or not a cow would step onto a moving platform. Many wise people predicted that she would not. So we built a wooden platform about 20 ft. long, mounted it on rollers, and divided the space on top into six stalls. The platform was towed past a fixed opening at a constant speed of about 15 ft. per min. Six cows were chosen at random for the test. All six stepped onto the platform without much hesitation.

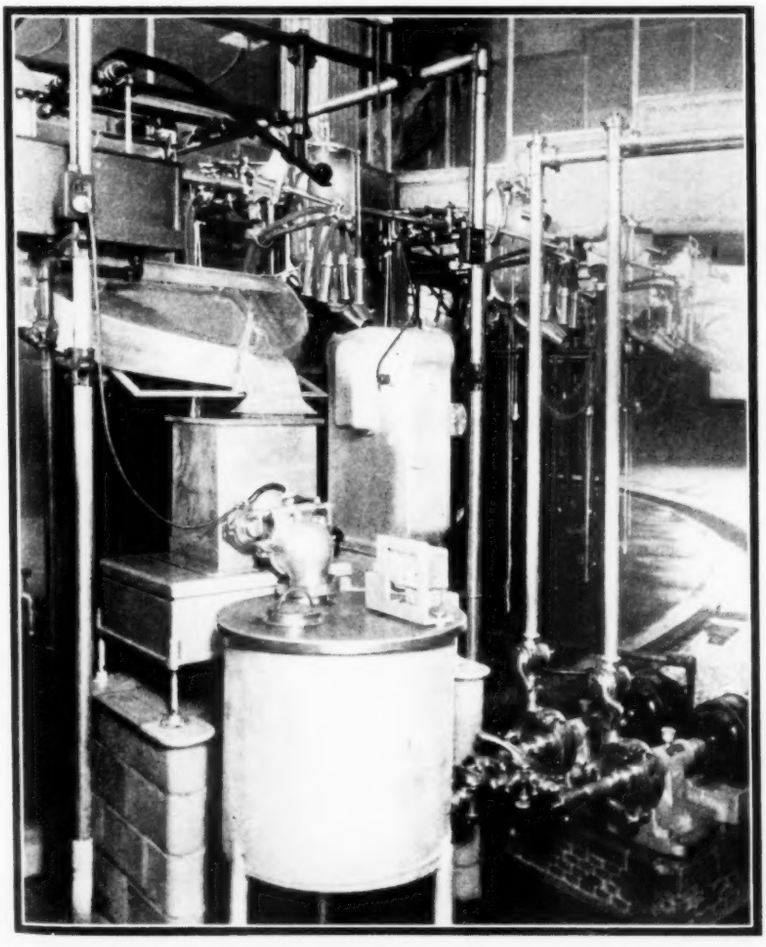
Next, we had to decide on a definite specifica-



CROSS-SECTION showing the Rotolactor as installed in the building. On the left side are shown two of the supporting wheels and one of the two motor driven vacuum pumps suspended from the table. On the right is shown one of the two driving units

tion of what we wanted to accomplish. Tentatively it was laid out that the cows be dry groomed, possibly by an automatic vacuum cleaner, then washed, dried, and milked. Whether to use hand or machine milking, one of the most important questions, was left open for future consideration. Later the idea of automatic dry grooming was abandoned as being too complicated to develop at this time. The rest of the program was finally and successfully worked out, following closely the original plan. Next we came to the question of milking machines. There seems to be an impression that the milking machine is harmful to the cow. This impression continues to exist with amazing persistence despite the educational efforts to dispel it. To our minds, the milking machine offered the finest opportunity to apply the idea of automatic mass production. Here was the chance to eliminate the possibility of human contamination of the cow or milk, and the opportunity to introduce a uniform milking action to which the cow reacts favorably. It only remained to balance the relative advantages and disadvantages of the various types of machines, and make our choice accordingly. After a survey of the field it was felt that the DeLaval machine could best be adapted to meet the conditions of our particular problem. The consulting engineer of this organization took an interest in our problem, and the many ingenious mechanisms which he developed opened up a vast field of new possibilities for the automatic milking. Meanwhile the design of the rotating table and driving mechanism was crystallizing, and finally reached a stage where construction was ready to begin.

A typical transverse section through the building and an oblique view from above the table showing the stalls and milking machine equipment are given. The table consists of a large annular ring about 8 ft. in width and 60 ft. in outside diameter. On this table are fastened 50 stall partitions radiating from the center of the circle, and to



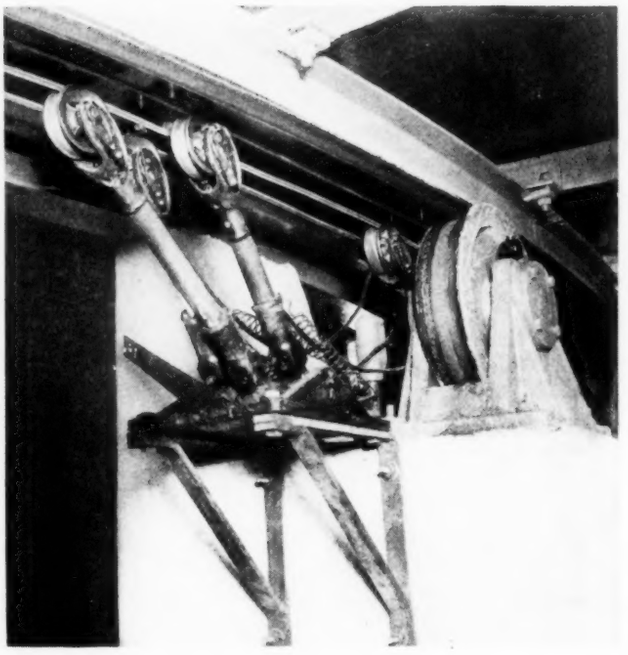
MILK is dumped into the scale tank and weighed automatically. A roller is starting on its cam track to lift the teat cups into the sterilizing trough. Milk piping and fittings are designed for quick assembly, as the system must be taken apart and washed thoroughly after each milking

these partitions are attached the milking machine jars, actuating valves, and vacuum pipes, together with the neck stanchions, or yokes, which are placed close to the inner wall.

Corrosion-resistant, 18-8 chromium-nickel steel was used in the original six experimental stanchions. It worked out successfully, but the shape of the stanchions was not adaptable to the conditions in the final design and consequently had to be discarded. In the final design, corrosion-resistant steel was again considered, but the new design called for several special cast fittings which cost too much. Furthermore, it was felt that even our best efforts in stanchion design would soon be obsolete. Mild carbon steel was therefore used.

The table was fabricated of structural plates and shapes and was surfaced with a concrete floor. To the bottom of the annular steel ring were bolted two standard 60-lb. rails bent in the form of a circle. They were made to rest on a series of supporting wheels in such a manner that the whole table could rotate about an imaginary center pivot. These wheels, really small diameter car wheels, were mounted on Timken bearings. It was essential, in a slow-moving heavy machine starting off under practically full load condition, that the starting friction be reduced to a low value, otherwise a high starting torque would be required, which would demand correspondingly larger electric motors. The sustaining oil film in a sleeve bearing would be squeezed out when the wheels stood at rest for a time, thus giving metal-to-metal contact with its resultant high coefficient of friction. The wheels were mounted in supports bolted down on concrete pedestals. Altogether, there are 28 supporting wheels.

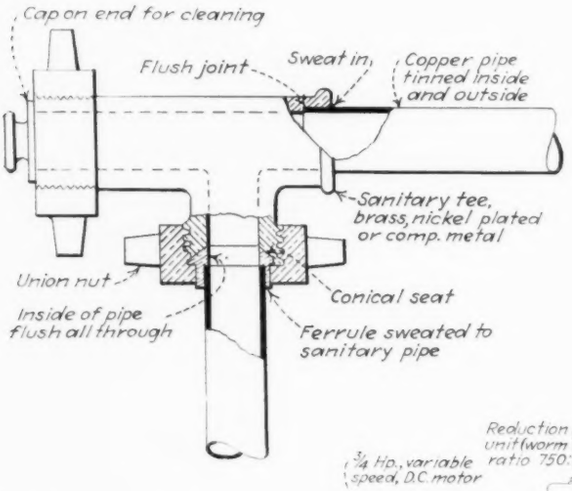
Plenty of ideas for driving the rotating table were forthcoming, such as a rack and pinion, belts, chains, or



TWENTY-EIGHT WHEELS support the table. Current for the motors and pulsator valves is collected through standard trolley wheels and harps

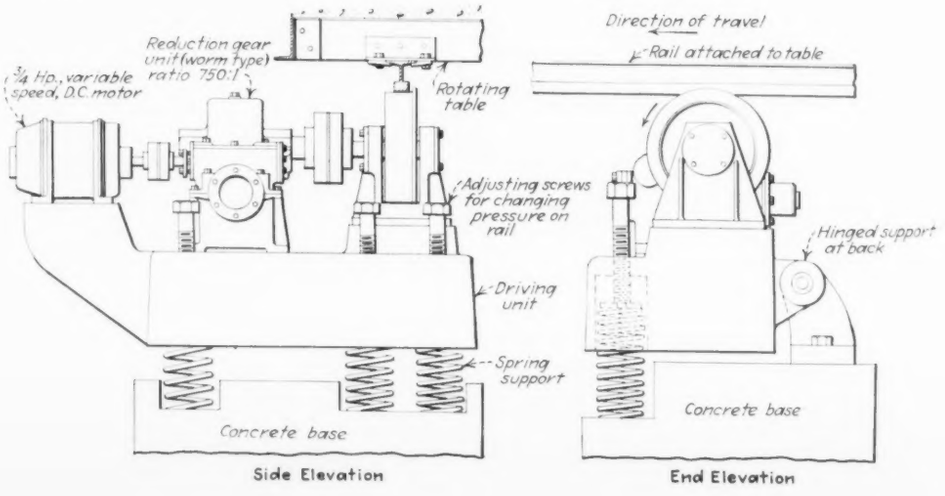
a center pivot drive like that used on merry-go-rounds. But all of these had disadvantages. When the idea of driving the table by means of friction through one or two of the supporting wheels was proposed, several thought the scheme would prove impracticable because there would not be enough traction in two ordinary car wheels to move an 80-ton table. The objectors seemed to think that teeth were necessary. But history told us that the same objection was offered to the first smooth-tread drivers on steam locomotives. In the end, we won the consent of the management to give our plan a trial. The friction drive is now successfully employed.

There are a total of four driving units. As shown in the illustration, they are hinged in back and supported by adjustable springs in front. By turning up on the bolts carrying the spring seats, any desired wheel load on the rail may be had. Each of these units weighs approxi-


Cap on end for cleaning
Flush joint
Sweat in
Copper pipe tinned inside and outside
Sanitary tee, brass, nickel plated or comp. metal
Union nut
Inside of pipe flush all through
Conical seat
Ferrule sweated to sanitary pipe

DETAIL of elbow bend in a sanitary milk line showing construction to procure continuous smooth walls and ease of disassembly for cleaning after each milking

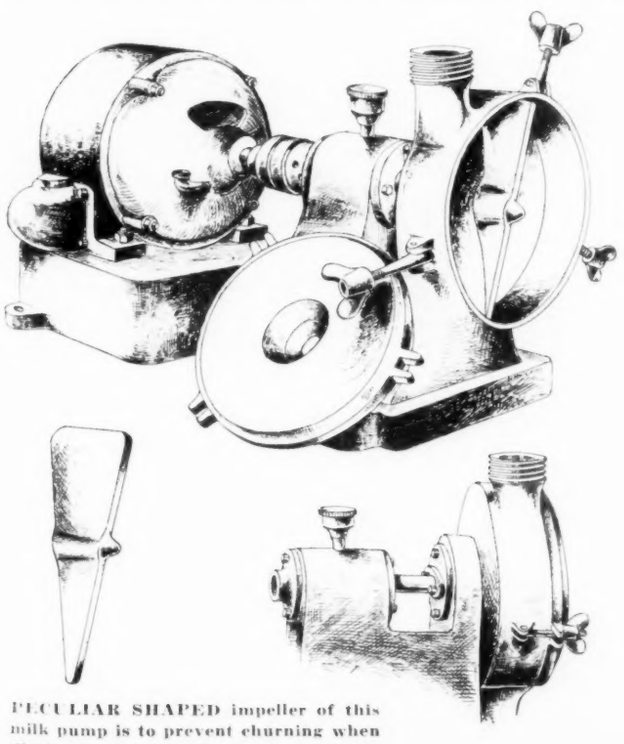
BRACKET carrying the roller cam for closing neck-stanchions, star-wheels for operating the valves, milk jars, and teat cups suspended in the water trough, are shown in this view



mately 2,000 lb., and presses upward against the rail with a force of about 5,000 lb. The power necessary to drive the table at its speed of one revolution in 12½ min. is, strange as it may seem, less than 1½ hp. This is divided equally between two diametrically placed driving units, thus obtaining a balanced drive. The other two units act as spares. The units have variable-speed d.c. motors and drive the wheel through a reduction gear having a ratio of 750 to 1. By means of a control board located in the machinery pit, the speed of the table can be varied from an upper limit of one revolution in 12 min. to a lower limit of one revolution in 20 min. Control is by means of rheostats in the field circuit of the motors.

As the rails are not exactly circular in form, the variation from exact roundness being about ½ in., plus or minus, the outer rail is greased so that it will slide freely, the slight amount required, across the tread of the wheel. If no grease were used, the movement of the rail across the face of the wheel would take place in a series of little jumps, or possibly in one big jump, severely jarring the table. This would make the cows nervous, and they would hold back their milk. Complete relaxation is an essential of thorough milking. The inner rail, being dry and firmly gripped by the driving wheels, does not have this lateral motion.

We had trouble finding a type of floor surface that would give the cow secure footing on a grade of 10 to 12 per cent. It had to be some material which would be non-slip either wet or dry, clean or dirtied. It had to be able to withstand constant washing down, waterproof, yet have a surface able to resist indentation. In collaboration with the Norton Company we finally evolved a technique in laying a rather coarse Alundum aggregate in a concrete matrix and then exposing the aggregate by brushing off the thin film of surface cement with a wire brush at a certain period of its drying and setting. A slightly rough surface is produced in this manner which, under all conditions, affords a sure footing for the cows. This flooring was used for the table and the cow runways and has proved satisfactory.



PECULIAR SHAPED impeller of this milk pump is to prevent churning when discharge ceases. The pump cover and propeller are removable for cleaning. Bearing is separated from pump to keep grease from getting into milk

In adapting the milking machines to the circular rotary table, the DeLaval company was consulted. The design of the units was modified three distinct times and numerous refinements of detail were developed before the present design was evolved. Many features were included in the milking apparatus applied to the rotary table that probably could not conveniently be used on any other milking system. The first of these is that all of the valves controlling the vacuum, the admission of sterilizing water to the glass jar, the releasing of milk from the jars, and the releasing of milk from the weigh tank are automatically actuated by the motion of the table itself. The second feature permits each milk jar, with the attached teat cups, to be completely rinsed and sterilized between milkings. Again, the weight of the milk from each cow is recorded in the same rotational order that the cows occupy on the milking table. The success of the entire record system is dependent on the absolute uniformity of rotational order in which the cows come through at each of the milkings.

ESSENTIALLY, the milking system has 50 units, each unit comprising a jar, two vacuum control valves, magnetic pulsator control, and teat cups with their attached rubber hose. There is one unit for every stall on the rotary table. Slung from the underside of the table are the two rotary vacuum pumps, together with two low-voltage motor generating sets for furnishing the current to the magnetic pulsator valves that control the pulsations of the vacuum. Both the vacuum pumps and motor generating sets are in duplicate. Should any trouble develop in one set, the load can be instantly thrown over on the other set. Such duplication was followed as far as possible in order to eliminate the possibility of delay from breakdowns.

Use of Pyrex glass jars was first decided on at a conference between the DeLaval company and ourselves. They have since been adopted by the former as standard equipment on their combine system. It is easy to see whether a glass pail is clean or dirty. The glass also has a psychological value in that visitors to the milking plant can watch the milk being discharged into the jar as it comes from the cow. The glass jars also permit visitors to see the complete rinsing and sterilizing process that takes place between each individual milking.

Regulating the rate of pulsations for milking added another problem. In the usual DeLaval milker there is but one circuit breaker to regulate the rate of pulsations on the udder cups: this outfit has six separate circuits. If the entire 50 pulsator valves were placed on one circuit they would cause a heavy surge on the generator and severe arcing at the breaker points, with consequent short life. Furthermore, if anything happened to a single circuit arrangement the entire 50 milking units would be affected. The function of the pulsator valve is to cause an alternate massaging and sucking action similar to the effect produced by a sucking calf. The entire milking system has been so designed that, in the event of a replacement, individual units or actuating valves can be removed and replaced within a few seconds.

The operation of the machine is simple. The cows enter in fixed order from a ramp and step onto the moving platform into individual stalls. A lever arm strikes a pinion and the stanchions lock the cow in. Warm water is sprayed on her flanks and udder. A moment later two men with hoses finish the washing and the

cow rides on through a sector where air from nine nozzles dries her in a minute.

A fore-milker tests the milk from each cow before the teat cups are attached. The vacuum is then turned on and the cow is milked for 8 min. A man removes the cups and hangs them up. The cow finds herself opposite an opening, the stanchions are released by a lever and cam contact, and the cow runs down a ramp and back to the barn.

Meanwhile a stationary finger strikes a star wheel on the milking unit causing air to draw in any milk left in the tubes. A second later the milk jar passes a collector spout. Again a finger strikes the star wheel, releasing the vacuum and letting the milk discharge into the collector where it is weighed automatically and its weight is recorded by an attendant. Then the milk goes on to a dump tank. The empty milk jars and the teat cups pass through a series of washing and rinsing troughs where they are completely cleansed before being attached again.

CHOICE of metal for parts that would contact with the milk was difficult. Milk has a marked ability to absorb odors and to take metals into solution. These metals give the milk an unpleasant taste out of all proportion to the amount of metal dissolved. The metal used must also have a dense, polished surface so that it can be cleaned and sterilized. One of the drawbacks in the use of stainless steel has been the difficulty of procuring the desired surface finish. Incidentally, chlorine affects stainless steel, and therefore when this metal is used sterilizing or cleansing agents containing chlorine must be avoided.

Tinned copper, solid nickel, and and glass-coated steel have until recently been the principal metals used for milk handling equipment, and high cost has mitigated against the use of solid nickel. Recently stainless steel has been making very rapid progress as a material for milk tanks, vats, and pasteurizers, but it is still considerably higher in price than the older materials. It is difficult to work, hard to machine, does not lend itself readily to soldering, and requires a technique in manufacturing and welding that all the manufacturers have not yet worked out in a completely satisfactory manner. Nevertheless it seems to have great future possibilities and we felt that it would be worth the expense to have the dump tank made of it. There has also been placed on the market an alloy of about 40 per cent nickel with the remainder copper and tin, which is available in the form of sanitary pipe, fittings, and pumps, thus eliminating the necessity of retinning the equipment at frequent intervals. This alloy we used for the milk pump that empties the dump tank.

As shown in the illustration, the shaft bearing of the milk pump is kept away from the pump casing proper so that there will be no possibility of grease leaking through the bearing and into the milk. The peculiarly shaped impeller blade is designed so that it will not churn the milk should the discharge of the pump be shut off. Churning would result in foaming when the milk is finally discharged into the holding vat. As the pump must be cleaned each time after it has been used, both the cover of the pump and the impeller are designed to be easily removable. White asbestos wick packing is used in the stuffing box where the shaft passes through the pump casing. The impeller shaft rotates in a pair of roller bearings.

+ + +

Books for Engineers

ECONOMIC CONTROL OF ENGINEERING AND MANUFACTURING. *By Frank L. Eidmann, professor of mechanical engineering, Columbia University. 402 pages, 6x9 in. Cloth board covers. Indexed. Published by the McGraw-Hill Book Company, 370 Seventh Ave., New York, N. Y. Price $4.*

WHEN one studies figures on the percentage of engineering graduates who eventually go into executive positions in industrial plants, it is immediately apparent that a book of the nature of this one is needed as a part of the equipment for a college training. Engineering cannot be merely setting down designs that will work; the economics of a product includes its manufacturing possibilities and its sales possibilities, and the engineer must be instilled early in life with a realization of the economic problems involved.

The book has twenty-one well-planned chapters, taking up such subjects as financial calculations, plant location, engineering for manufacture, economic use of materials, selection of equipment, tool engineering, standardization, marketing policies, and industrial working conditions. Although originally planned as a textbook, it should also be a valuable book for any practical engineer who desires to get a well-rounded review of the economic aspect of engineering.

+

INDUSTRIAL ACCIDENT PREVENTION, A SCIENTIFIC APPROACH. *By H. W. Heinrich, Assistant Superintendent, Engineering & Inspection Division, The Travelers Insurance Company. 366 pages, 5½x8 in. Indexed. Cloth board covers. 153 illustrations. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Price $4.*

FUNDAMENTALS of industrial accident prevention, together with necessary explanatory detail, are here presented. Engineers and designers will find Chapter VIII, "Machines, Prime Movers, and Power Transmission Guarding," of particular interest. In this chapter the author describes and illustrates a wide variety of safety devices applied to tools and machines, giving standards for guarding and explaining the principles involved. The general arrangement of material permits ready understanding and shows how the control of accident frequency and cost may be obtained in any industrial operation, regardless of the size or nature of the work. The volume is unusual in that its entire content is summarized in the first chapter, the remaining chapters being devoted to expansion and explanation of the principles by examples. Practically all of the illustrations are actual photographs of types of safety devices applied to machines in a wide diversity of industries.

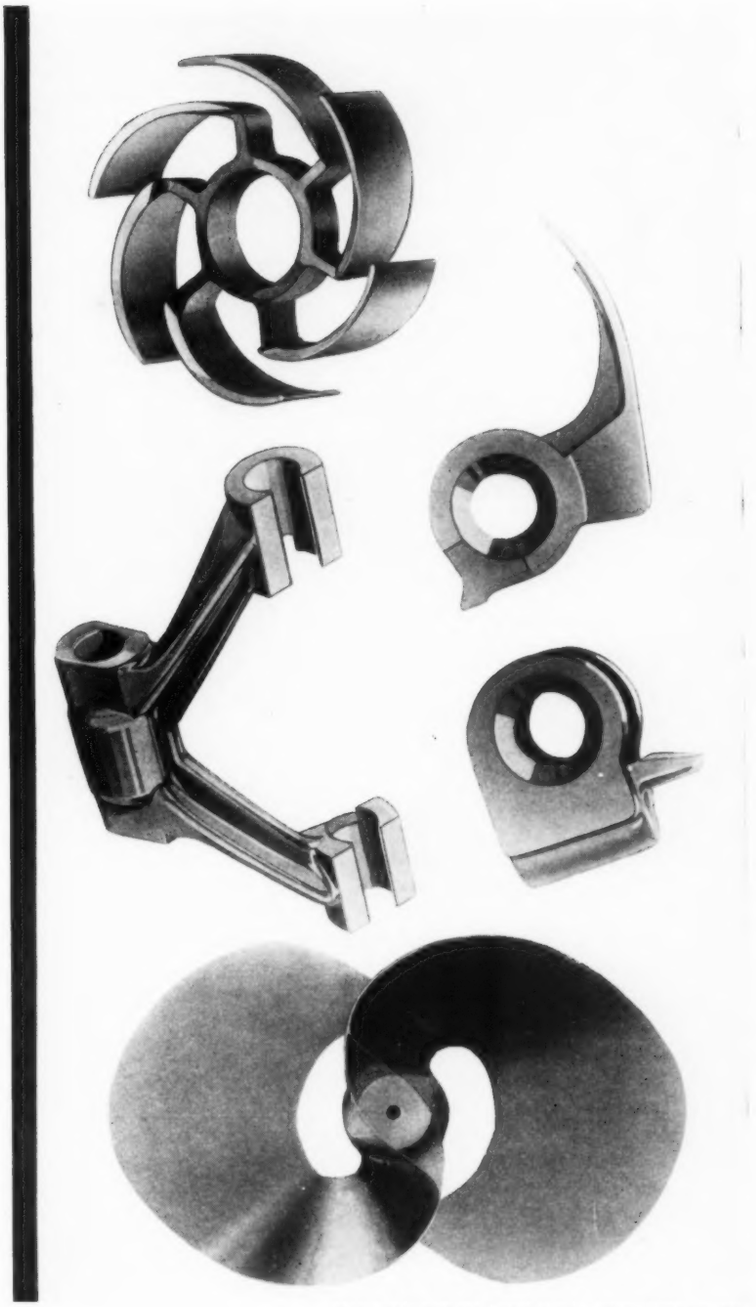
The book collects and summarizes the vast mass of material already written on safety and accident prevention, and endeavors to offer a scientific approach. Its principal value, however, is as a collection of good safety device illustrations.

INTRICATE SHAPES in Aluminum Bronze

DIE-CASTING of aluminum bronze is now being applied to comparatively intricate shapes, thus opening to the designer a new field for this group of highly corrosion-resistant alloys. Though having high strength, no deterioration through aging, and the ability to be heat-treated, this group is not readily machinable because of the free aluminum oxide present. Hence, precision die casting or forging must be used to form accurate or intricate parts.

In the parts here illustrated, an alloy containing 89 per cent copper, 10 aluminum, and 1 iron was used. This alloy is grouped with the high-strength, iron-bearing aluminum bronzes. As die cast under pressure, parts had tensile strengths of 85,000 and Brinell hardness of 140, which could be increased to 100,000 lb. per sq.in. and 260 Brinell by heating to 1,700 deg. F. and quenching in water. These alloys melt at 1,950 deg. F., and have a tensile strength of 19,000 at 1,000 deg. F.

In die casting a part having relatively large areas of thin surfaces, like the electric dishwasher impeller shown at the bottom of the group, the casting must be designed so that the metal may flow through thicker sections into thinner ones.



Photographs from the Aurora Metal Products Company, Inc.

The same principle must be applied in designing the dishwasher centrifugal pump rotor at the top. In the printing press spring gripper and spring gripper holder at center right, the holes are cast conical to facilitate core removal, the holes being drilled and reamed after casting.

Holes requiring long steel cores are not found practical because the alloy shrinks upon the cores and prevents their removal. In the roller yoke bracket for a variable-speed transmission, center left, in which it is necessary that the side holes be parallel with the center hole, solid steel cores are used in the ends, and a thin steel tube bushing in the center hole. After cooling, the bushing may be removed easily, even though reduced in diameter, and the open sides permit removal of side cores.

✦ ✦ ✦

Roller Chain Drives

IN THEORY AND PRACTICE

By G. M. BARTLETT

Associate Professor of Machine Design, Purdue University
Consulting Engineer, Diamond Chain & Manufacturing Company

ROLLER transmission chains are made in pitches ranging from $\frac{3}{8}$ inch to 3 inches, and they are made in either single or multiple widths. The field of application is very extensive, covering such a range as: bicycles, motorcycles, motor trucks, cam shaft drives for motor cars and Diesel engines, agricultural machinery, machine tool drives, motor-to-line-shaft drives in all industries, automatic machines of all kinds, baking, canning, mining, shoe and textile machinery, speed reducers, pumps, hoists, lawn mowers, industrial locomotives and stokers.

As only short-pitch chains can be used for high sprocket speeds, and only long-pitch roller chains can be used for heavy loads, it is evident that neither type is adapted to heavy loads at high speeds. Until the multiple roller chain was developed, this demand could only be met by the particular type of chain known in England as the "inverted tooth" chain and in America as the "silent" chain. Such a chain is built in various widths. The requirements for high speed are met by using links of short pitch, and the requirements for power are met by widening the chain. This has the effect of increasing both the bearing surface of the pins and the tensile strength of the chain. Another property possessed by the "silent" chain is that of exceptionally quiet action even at high speeds.

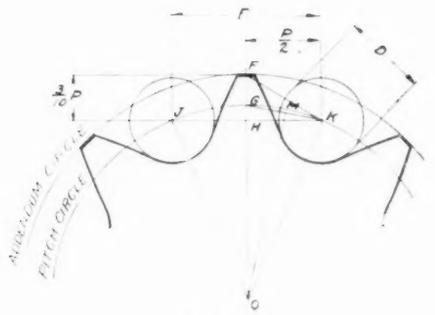


FIG. 2
DIAGRAM for deriving relationship of pitch diameter to pitch and number of teeth

During the past eight or ten years multiple-width roller chains have been rapidly introduced where higher power must be transmitted at high speeds. These chains are built in double, triple, quadruple, and quintuple widths, and it is now possible for roller chains to fill the majority of demands for positive transmission of power at high speeds and under heavy loads. As in the "silent" chain, quiet action is secured by the short pitch of the chains made possible by using multiple widths. The efficiency of such chains is inherently higher than that of equivalent single-width chains.

The present article will deal mainly with sprocket design, it being assumed that the reader is familiar with the general construction and proportions of standard roller chains.

All chain wheel tooth forms have one object in common, namely, to make provision for the proper function-

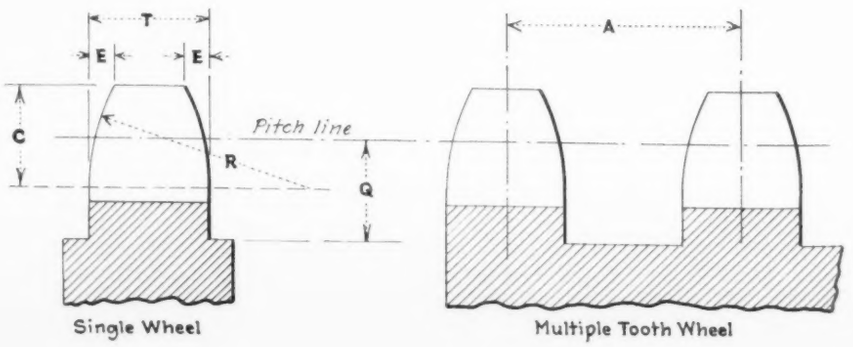


FIG. 1
STANDARD PROPORTIONS of sprocket tooth sections given in the text are laid out as shown

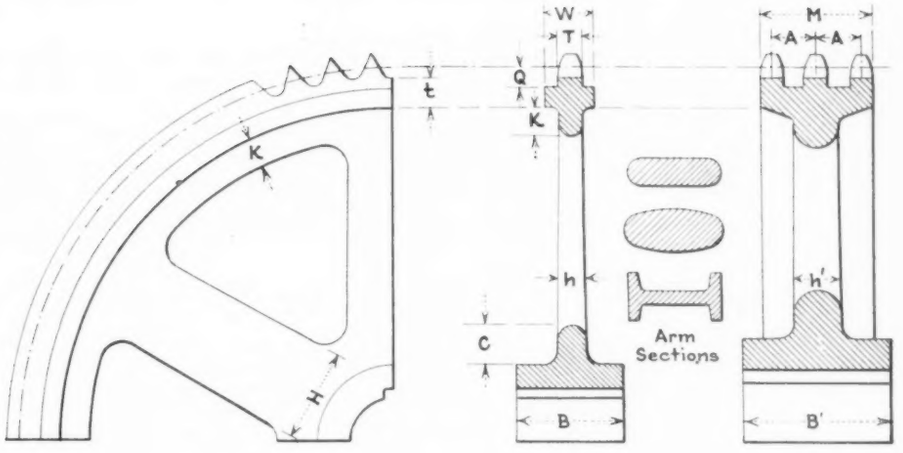


FIG. 3
FORMULAS are given in the text for calculating the lettered dimensions

ing of the chain, not only when new and true to pitch, but also after it has elongated from wear.

In the oldest tooth form the spaces between the teeth were made extra wide, creating a considerable amount of "pitch-line clearance," which required a single roller to carry the whole load. The pressure angle had to be small in order to prevent the roller from slipping over the top of the tooth. These conditions induced rapid wear at the base of the teeth, making them hook-shaped. The action was also jerky and noisy because as each roller passed out of action the following roller came into contact with a snap.

The first improvement, the Renold tooth form, abolished the pitch-line clearance and increased the pressure angle. Angle of the tooth gap was 60 deg. for all numbers of teeth above 6, which caused the pressure angle to increase with the number of teeth. The large pressure angle allowed all of the rollers of an elongated chain to act at higher points on the teeth, the chain automatically adapting itself to such positions on the sprocket teeth as best suited its condition. On this principle standard British sprockets are now designed.

In America a tooth form designed by the author and known as the "Diamond" tooth form was used for a number of years prior to the introduction of the present standard. It, too, discarded the old pitch-line clearance, but differed from the Renold form in that it used a constant pressure angle of 20 deg. for all numbers of teeth, necessitating a variable tooth gap angle.

The first of a series of articles on the design and application of roller chain drives. In this article Prof. Bartlett comments on roller chain problems and gives details for the proportioning of standard sprocket teeth and wheels

Both the British and Diamond forms gave good results, and the question as to whether the constant or the variable pressure angle is best has never been settled. However, the American Standards Association took the middle ground and designed the present American tooth form with pressure angles between those of the Renold and the Diamond teeth. An added feature was the introduction of a curve "concave" with respect to the roller, thus giving better wearing contact and still further lengthening the life of chains and sprockets, besides reducing noise. Also, the load is divided among a number of teeth, and each tooth and roller assumes its load gradually instead of suddenly. Where the rollers are acting at higher points along the teeth the roller approaches the side of the tooth at an acute angle instead of a right angle. These facts account very largely for the quietness of present day roller chains.

Sprockets with cast teeth are frequently used when the speed is not high and a great many sprockets are to be made from the same pattern. Such sprockets, of course, are neither as accurate nor as efficient as when made with cut teeth, but are decidedly economical. Provision must be made for greater clearance in the spaces between the teeth on account of the rough cast surface.

Referring to Fig. 1, let P = pitch of chain; W = width of chain; H = nominal thickness of inside plates of chain. The thickness T of the sprocket must allow for the free passage of the side plates over the teeth under all usual conditions. Standard proportions are:

$T = 0.93\ W - 0.006$ in. (for single width chains)
$T = 0.90\ W - 0.006$ in. (for double and triple width chains)
$T = 0.88\ W - 0.006$ in. (for quadruple width and over)

Width of chamfer, $C = \frac{1}{2} P$
Depth of chamfer, $E = \frac{1}{8} P$

The radius R is theoretically equal to $1.062\ P$; but in practice it may be considerably greater than this, and the same forming tool may be used for three or four sizes of sprockets.

Center distance, $A = W + 4.15\ H + 0.003$ in.

The standard tolerance on sprocket thickness T is $\pm \left(\frac{W}{50} + 0.002\right)$ in., but some manufacturers consider that a tolerance of $\pm \left(\frac{W}{100} + 0.002\right)$ in. is sufficient.

The pitch diameter is calculated from the formula

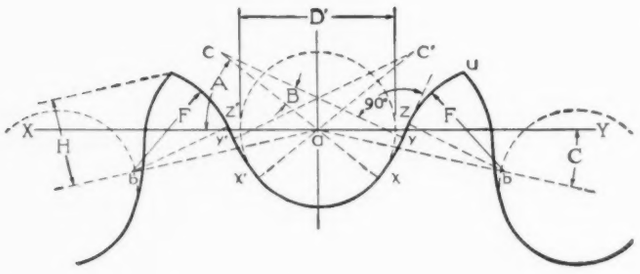
$$\text{Pitch diameter} = \frac{P}{\sin \frac{180}{N}} \qquad (1)$$

where P is the pitch and N is the number of teeth. The derivation of this formula will be easily understood by reference to Fig. 2, where the angle KOH is equal to 180 deg., KH being equal to half the pitch, and OK half the pitch diameter. Two rollers are shown in the tooth spaces, the distance JK being the pitch of the chain.

The bottom diameter is the diameter of the circle tangent to the bottoms of the tooth spaces. It is found by subtracting the roller diameter D from the pitch diameter.

In the manufacture of sprockets the bottom diameter is not allowed to be oversize. It may be undersize, however, to the extent of 0.003 in. + 0.001 $P\sqrt{N}$.

Table of proportions of American Standard Sprocket Tooth Form



P = Pitch; D = Nominal roller diameter; N = Number of teeth.

$$D' = 1.005D + 0.003 \text{ in.}; \quad A = 35° + \frac{60°}{N};$$

$$B = 18° - \frac{56°}{N}; \quad ac = 0.8D; \quad C = \frac{180°}{N}$$

Draw line xac making angle A with line XY and locate point c so that $ac = 0.8D$. Draw line cy making angle B with line cx. With center at c and radius cx, draw arc xy for the "working curve."

Draw line yz perpendicular to line cy. Draw line ab making angle C with line XY, and locate point b so that $ab = 1.24D$. Draw line bz parallel to line yc. With b as center and radius bz, draw the "topping curve," arc zu, tangent to line sy.

Outside diameter of sprocket, pointed tooth $= P \text{ Cot} \frac{180}{N} + 2H$.

Recommended value for H is $0.3P$, in which case the outside diameter of the sprocket will be $P\left(0.6 + \text{Cot } \frac{180°}{N}\right)$.

Pressure angle of new chain is $xab = 35° - \frac{120°}{N}$.

Min. pressure angle is abz, or $17 - \frac{64°}{N}$.

Avg. pressure angle is $26° - \frac{92°}{N}$.

The outside diameter is usually determined from the formula:

$$\text{Outside diameter} = P\left(0.6 + \cot\frac{180}{N}\right) \qquad (3)$$

It is entirely permissable, however, to increase this as much as 0.1 P if desired, thus making the teeth practically pointed.

Tables giving pitch, bottom, and outside diameters of sprockets, are usually to be found in the catalogs of roller chain manufacturers.

Sprockets are commonly made in one of four types described as follows: The plain type has bolt holes for fitting to flanges or hubs. For diameters above 9 in. it is best to attach a plate type to a detachable hub, rather than to provide an integral hub on one or both sides. If large quantities are involved, a cast armed sprocket is cheaper in the larger sizes. Sometimes a split hub is desirable where the sprocket is to be mounted between fixed bearings which are not to be disturbed. In this case the sprocket plate is split at right angles to the split in the hub.

Armed sprockets are usually made of a good grade of cast iron or of semi-steel. The arm is commonly of elliptical cross-section. A few formulas for the design of arms, rim, hub, and bead for this type of sprocket are given below in connection with Fig. 3.

Let a be the number of arms, P the pitch, and N the number of teeth.

$$\text{Thickness of rim } t = \frac{P}{7}\sqrt{\frac{N}{a} + 10}$$

Depth of bead, K = 1 to 1.25 times t, but not less than $\frac{1}{4}H$.

Hub diameter = about 1.8 times bore.

Hub length, B = about $1\frac{1}{4}$ times bore, but not less than width of rim, M.

$$\text{Width of arm } H = P\sqrt[3]{\frac{Nn}{a}} \text{ approximately, where } n$$

is 1 for a single chain, 2 for a double chain, 3 for a triple, and so on.

Thickness of arm, $h = \frac{1}{2}H$ for multiple chains, but T for single chains. The section may also be oval, or I-shaped as shown in the figure, but the above formulas are for elliptical sections.

These are the dimensions of the arm at the center of the hub and the arms may be tapered 1 in. in 48 in. toward the rim without weakening them. The bead depth C at the hub may be made about 0.22 times the bore. If there is a flange, the distance from the pitch circle to the flange is about equal to half the pitch, and must be sufficient to clear the side plates. The width of flange, W, may be made equal to the chain width plus half the pitch. For a square key, the width of keyway is equal to about one quarter the bore.

By laying out the sprocket to scale according to the above proportions the designer can make such alterations as good judgment may dictate. Armed sprockets are frequently made of the split type so that the two halves can be clamped together over the shaft, the key sometimes being omitted.

In designing small sprockets, care must be taken to provide proper clearance between the hub and the side plates of the chain. The widest side-plates used in practice measure about 95 per cent of the pitch. To provide for side-plates of this width it is necessary to make the hub diameter somewhat less than the pitch diameter minus 0.95 P; usually pitch diameter minus pitch.

If the load on the chain is jerky or pulsating, the life of the drive may be greatly extended by providing some form of shock absorbers. In one type the rim drives the hub through a set of springs initially compressed sufficiently to carry the average load without further compression. Any excess load is carried through the springs and sudden shocks on chain and shaft are avoided. On account of their expense such sprockets are not widely used.

Compactness and Light Weight

GOVERN MOTORCYCLE DESIGN

WILLIAM S. HARLEY

Chief Engineer, Harley-Davidson Motor Company

ENGINEERS who assume that little progress has been made recently in motorcycle design are mistaken. Motor cycles are limited chiefly to the three broad fields of traffic control, delivery service, and so-called "sport" riding, but their development has not been impeded by this limitation. Today we feel that our machines compare favorably with the best standards of automotive practice. In fact, chiefly because of space and weight limitations, and speed and power requirements that necessitate operation at temperatures higher than those encountered in aircraft engines, greater refinements in design than are found in the average automobile have been required. Another consideration is the comfort of the rider, who sits directly over the engine.

The new model VL Harley-Davidson machine has a V-twin engine of 3 7/16-in. bore and 4-in. stroke, giving a displacement of 74 cu.in., and developing 32 b.hp. at its top speed of 4,600 r.p.m. This corresponds to a ground speed of 90 m.p.h. (wheel speed 100 m.p.h. because of slippage). The compression ratio is 5 to 1, as in average automotive practice. In special racing models, however, much higher compression ratios are employed, and as high as 1 hp. per cu.in. of displacement is possible.

Perhaps the most unusual feature of the engine is the built-up crankshaft having roller bearings on the crankpin and on one main bearing. The crankpin is anchored with a taper fit in the cheek of each of the two cast-iron flywheels, and the stub shafts for the main bearings are keyed and clamped in the flywheel hubs. This construction conserves space and permits the use of rollers bearing on the crankpin and an uninterrupted raceway in rods without detachable caps.

Hardened and ground plates are set into the flywheels at the crankpin and at the roller bearing end of the crankshaft to take side thrust without undue wear. Because of space limitations, one flywheel is wider and heavier than the other. Flywheels of small diameter are necessary to keep the over-all height of the engine within limits under the saddle.

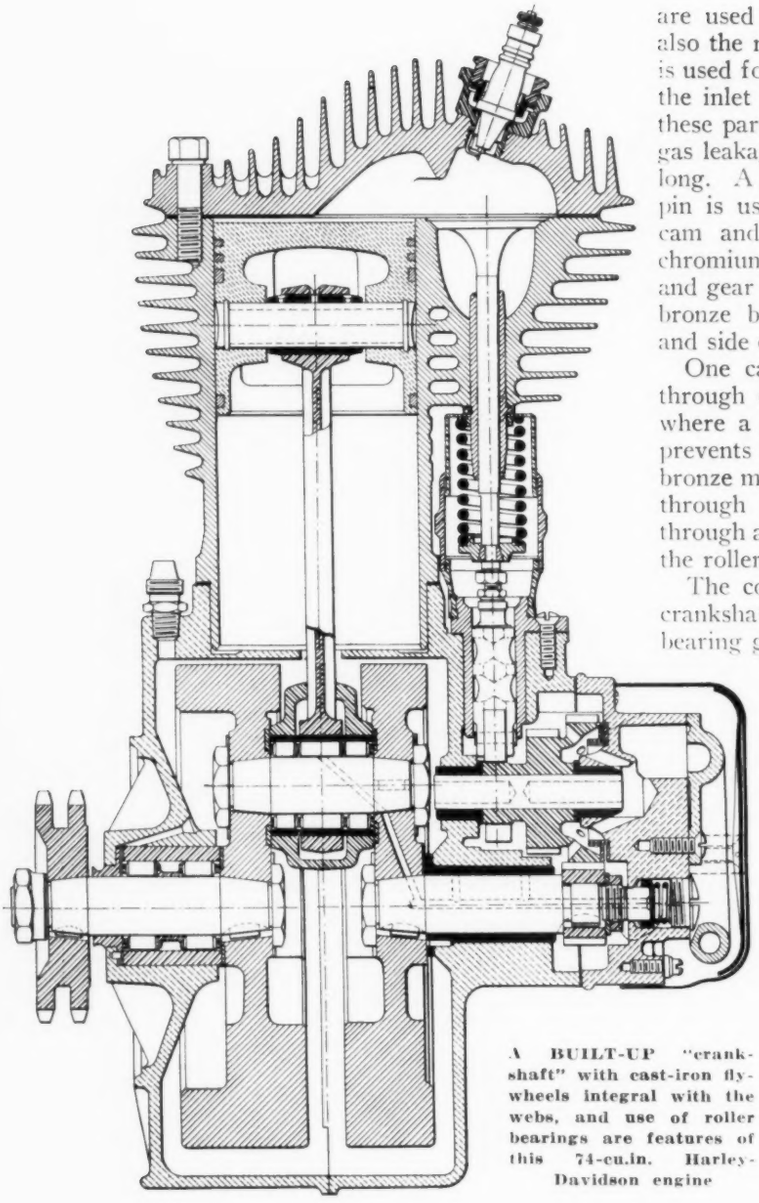
A baffle cast integral with the crankcase and separating it from the cylinder chamber prevents too much oil being splashed into the rear cylinder.

Outer races, and the $\frac{1}{4}$-in. diam. rollers are made of S.A.E. 52100 chromium ball steel. Races are ground and lapped after they are pressed in place in the rod ends. The crankpin, which forms the inner race, is carburized to a depth of $\frac{1}{8}$ in., hardened, ground and lapped. Rollers also are lapped before assembly to assure long life.

One connecting rod is articulated to straddle the other. Both have H sections and are forged from S.A.E. 1040 steel, heat-treated. The hollow piston pins are carburized, hardened to 60-65 Rockwell, and ground. They are located by lock rings in the Lynite pistons and float in the pistons and in bronze rod bushings. Pistons are of conventional design with four rings, two compression and two guide rings.

Allowance is made for unequal expansion of the cylinder by tapering the bore 0.001 in. per inch, with the largest diameter at the base so that, at operating temperatures, the bore is approximately straight.

Ricardo-type cylinder heads are made of nickel cast iron. Solid corrugated copper gaskets, which withstand the high temperature and pressures without blowing out,



A BUILT-UP "crankshaft" with cast-iron flywheels integral with the webs, and use of roller bearings are features of this 74-cu.in. Harley-Davidson engine

are used between heads and cylinders. Nickel-iron is also the material of the valve guide bushings. Silcrome is used for the exhaust valves and chrome-nickel steel for the inlet valves. Since no attempt is made to lubricate these parts, a loose fit is allowed to prevent seizure, but gas leakage is prevented by making the guides relatively long. A nickel-iron bushing bearing on a hardened steel pin is used for the tappet roller which, as well as the cam and integral gear, are of S.A.E. 3115 nickel-chromium steel, carburized and hardened. Each cam and gear unit is pressed onto a drilled shaft revolving in bronze bushings pressed into the aluminum crankcase and side cover.

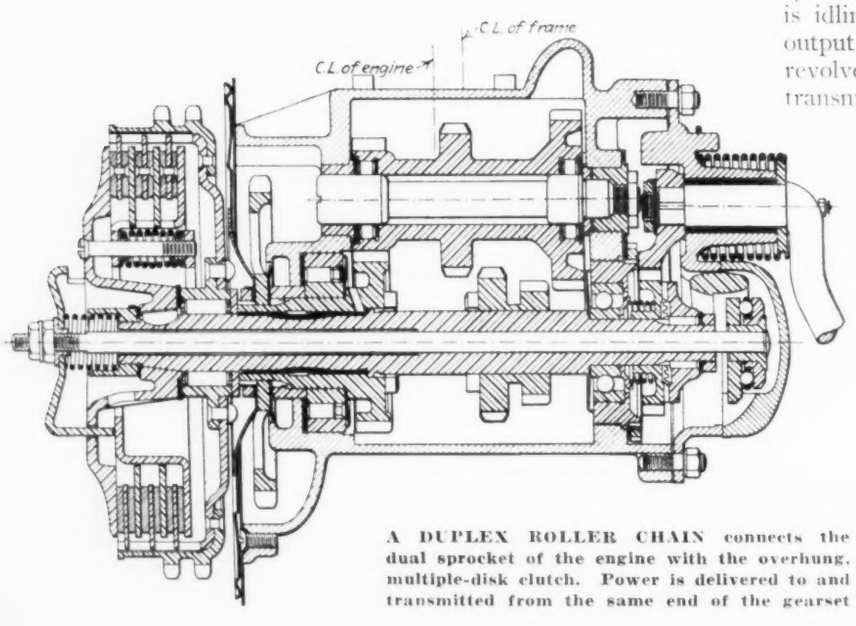
One camshaft gear drives a pump which forces oil through drilled passages to the end of the crankshaft, where a packing gland under constant spring pressure prevents oil leakage into the crankcase. Oil enters the bronze main bearing and also the crankpin roller bearings through drilled holes. Splash lubrication, applied through a drilled passage in the crankcase, is sufficient for the roller bearing at the sprocket end of the crankshaft.

The combination of roller and plain bearings on the crankshaft has been entirely successful and the roller bearing gives the added capacity for the overhung chain load. For the past two years a duplex chain sprocket has been used with resultant increase in chain life. The sprocket is made from S.A.E. 3115 steel, carburized.

Unusually high operating temperatures have necessitated the adoption of a special spark plug. Instead of clamping the porcelain to the body with a single copper gasket, a disk spring washer and a body twice the normal diameter is employed. This spring exerts sufficient pressure on the lower copper gasket to keep it gas tight even though appreciable expansion in the plug body takes place. Radial holes are drilled in the main body for air cooling.

Since the power input and output sprockets, as well as the multiple-disk clutch, are on the same side of the transmission case, a somewhat involved construction is necessary. A clutch release rod passes through the hollow main shaft, upon which the driven duplex sprocket assembly revolves when the engine is idling. Carried on the same shaft is the output sprocket and gear assembly which revolves on a split bronze sleeve when the transmission is "in gear." The constant-mesh gear is on the output end of the transmission. Cylindrical rollers without either inner or outer races support the cluster gears on the dead countershaft, which is held in replaceable steel bushings at each end.

The ball bearing on the main shaft also is supported in a steel sleeve, which is screwed into the aluminum housing, to provide axial adjustment. A hardened steel washer at the opposite end of the shaft takes any end thrust. Both anti-friction bearings on the main shaft have a disk baffle to exclude gear lubricant. Separate lubrication is provided through Alemite fittings.



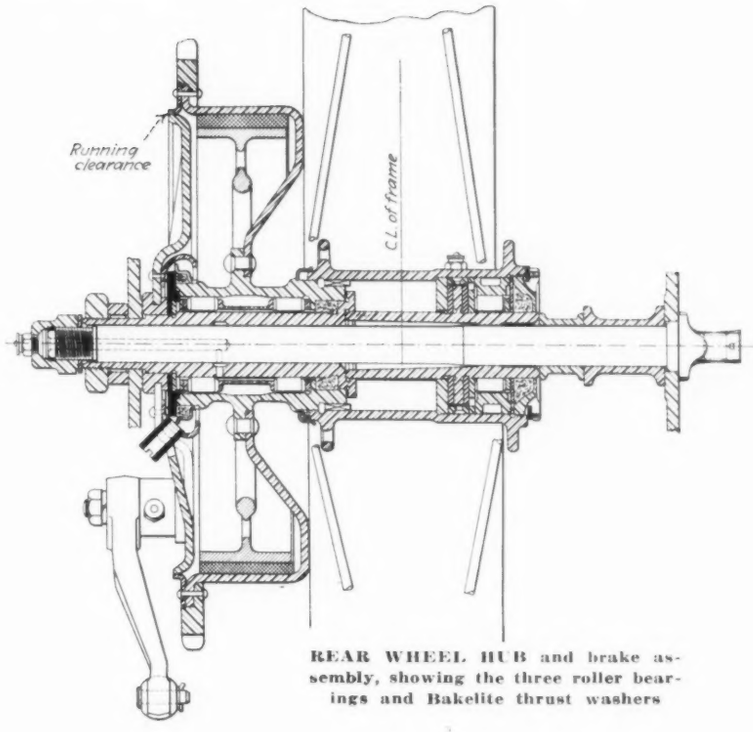
A DUPLEX ROLLER CHAIN connects the dual sprocket of the engine with the overhung, multiple-disk clutch. Power is delivered to and transmitted from the same end of the gearset

Engine starting is effected by a kick-over device on the right side of the transmission. This device comprises a pedal crank, returned by a helical spring, and a gear sector which can be brought into contact with a pinion connected to the main shaft through a ratchet arrangement.

The clutch driving member is a forging riveted to a pressed steel shell, the side of which is slotted to support the driving disks. A forging is also employed for the hub which is carburized, hardened, and ground on the inside to form the outer race of the idler roller bearing. The driven clutch member is a malleable casting. Most of the gears and shafts in the transmission, as well as the driver sprocket, are S.A.E. 3115 steel, carburized and hardened.

Control of the clutch is by a throwout with a ball thrust bearing and a radius arm brought back over the top of the transmission. On the arm is an interlocking stud that engages a slotted gate in the gear shifting shaft and prevents shifting when the clutch is engaged. The tension of the front chain is regulated by moving the transmission backward or forward by means of an adjusting screw. The rear chain is adjusted at the rear hub, which is also designed for easy removal.

For safety considerations the duplex chain connecting the transmission and the engine is completely inclosed, and a metal guard is placed over the upper strand of the coarse-pitch single chain leading to the rear wheel. For convenience in starting, a simple knob on the end of a plunger gives a fractional movement to the starting gear, should engagement with the sector gear be impossible because of the relative positions of the toothed members. A helical spring returns the knob to position when it is released.



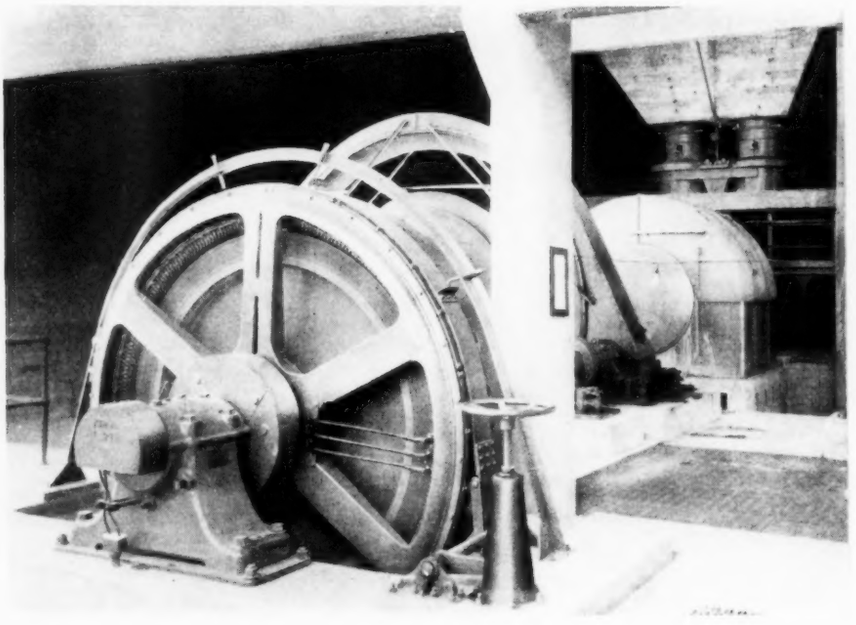
REAR WHEEL HUB and brake assembly, showing the three roller bearings and Bakelite thrust washers

AN ingenious construction of the rear wheel hub makes it easy to dismount the rear wheel readily for tire changing, in about a half minute without disturbing the chain or brake assembly and without exposing the bearings. Moreover, front and rear wheels are interchangeable. At the rear hub two major parts—the wheel hub, and the sprocket and brake assembly—are joined by internal and external splines. To drop the wheel, a hinged section of the mudguard is folded back, the outer nut at the left is removed and the central axle is tapped out toward the right. With the axle out, the spacer spools between the wheel hub and the right fork are dropped and the wheel is pulled off the brake hub. This leaves bearings and enclosures intact, with the brake hub sleeve supported in the left fork.

Side thrust on the wheel hub is taken between Bakelite disks and a flange on the central sleeve. Three cylindrical roller bearings with races integral with the hub parts support both the wheel and brake assembly. For these parts, S.A.E. 3115 steel, carburized, is the material selected. Other parts are of S.A.E. 3140 oil-hardening steel. The brake drum is drawn from low-carbon screw stock. Parts of the internal expanding brake are completely enclosed to assure efficient performance under all weather conditions. Well-enclosed felt washers prevent grease from the bearings reaching the brake surfaces. Wear in the roller bearings is taken up by substitution of oversize rollers.

Spokes and the kickout pedal are cadmium plated and wheel rims are enameled, but all bright work is chromium plated. Frame and gas tank receive an enamel and varnish finish. The frame is made of seamless steel tubing, brazed at the joints. The handle bars, however, are welded. Black work, such as the muffler and the kickout crank and helical return spring, as well as the springs on the front fork, is Parkerized. The cylinder blocks are enameled. No finish is required on the alumium crankcase, but the steel valve stem covers and the pressed steel cover on the right side of the crankcase are cadmium plated.

THE motorcycle has been by no means replaced by the light type of automobile. Nor is it merely a piece of "sport" equipment. The State traffic departments demand a speedy, easily controlled, sure-starting, powerful machine that requires little or no service in operation. The military use of motorcycles for high-speed reconnaissance service has also placed exacting demands on the designers. To light weight and minimum dimensions has been added the factor of perfect balance in the power plant because of its operation on two wheels. The modern design of machine has so far met these conditions, and can be operated so economically that its market has been extended to the field of light delivery in competition with the smaller types of automobiles.



EXTERNAL revolving field synchronous motor driving a crushing mill. The handwheel in the foreground operates the steel band brake around the frame

ELECTRIC MOTORS

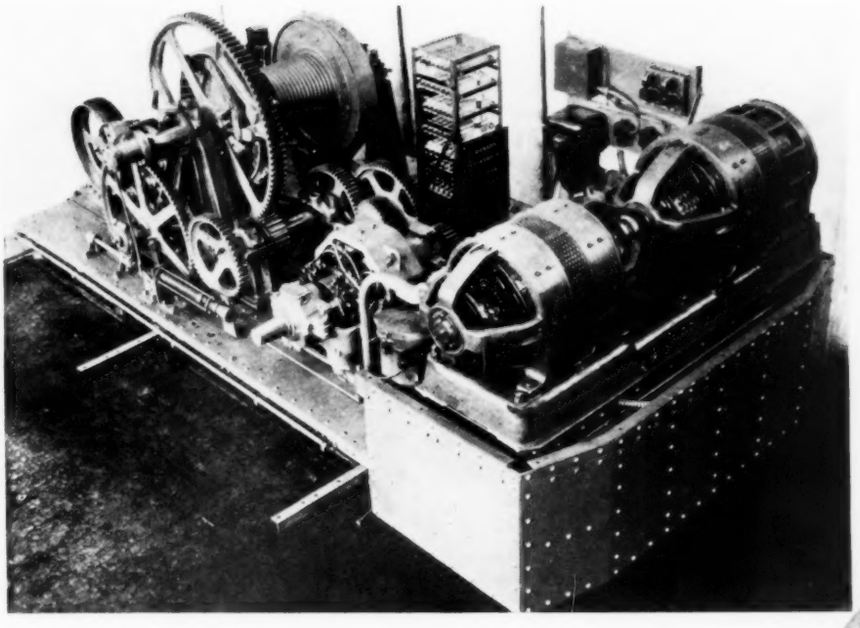
for inertia and torque requirements of the driven machine

Fourth of a Series of Articles

ELECTRIC motor design permits the production of motors having widely differing characteristics, but for commercial reasons the most useful groups of characteristics are embodied in the types of motors listed by the manufacturers. Special groupings and over-emphasis of certain characteristics are found in special motors designed for specific purposes. When it is considered that mechanisms or devices driven by motors also vary just as greatly in their characteristics, it is evidently quite possible, and it not infrequently happens, that otherwise well designed machines have unsuitable motors applied to them. Such mis-alliances may work for years, though constantly taking toll in under-production and over-maintenance. Hazards that are not readily recognized may be introduced, causing endless trouble and condemnation of the product. To bring together motors, machines, connections, and control of such natures that successful team work shall ensue requires the designer of the motor-driven product to follow the recommendations of engineers who have specialized in the design and application of motors.

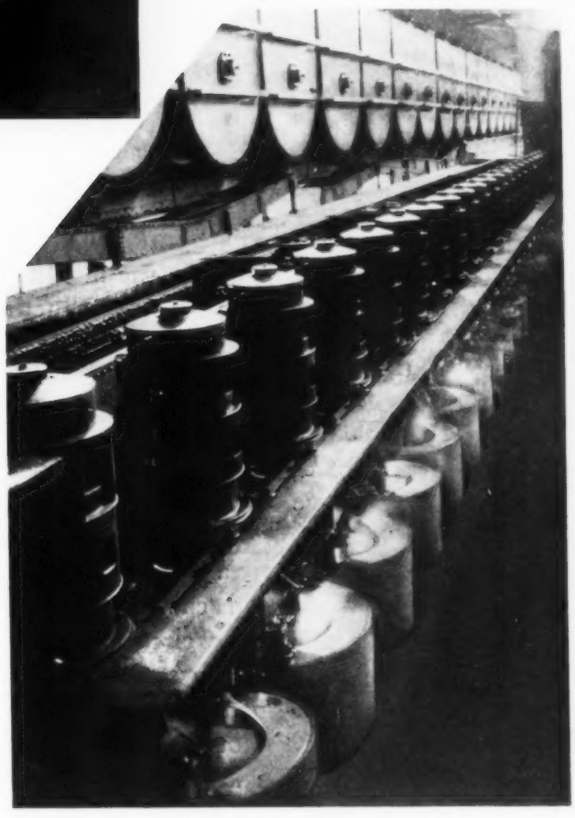
Ability to develop the required starting torque is one of the governing factors controlling the selection of a motor. Though for most machines necessary starting torque usually can be figured readily either by theoretical calculation or from data on similar machines, engineers sometimes neglect to give this important item sufficient consideration when specifying a driving motor. Two machines, both designed for the same purpose and both requiring the same running torque, may, by virtue of differences in their design, demand greatly different starting torques.

Even machines that are not started under load may require a comparatively high starting torque to accelerate properly the rotating and reciprocating parts. If the acceleration is too slow, the motor may burn out. The inertia energy that must be supplied in accelerating the elements from



REVOLVING FRAME of an electric shovel with machinery and Ward Leonard control in place

CENTRIFUGAL sugar dryers driven by 1,200 r.p.m. high-torque induction-type motors. The dryers are speeded up for 1 min., and slowed down by dynamic braking for ½ min., the cycle then repeating



Illustrations from General Electric Company

rest up to rotating speed is equal to one half the moment of inertia times the square of the angular velocity. In addition, frictional resistance must also be overcome. By a proper combination of speed, lightness of construction, compactness and bearings design, the amount of energy required to overcome inertia and frictional resistance in starting can be reduced to a practical minimum.

When a direct gear drive is used, the highest speed of rotation is usually that of the motor shaft. Evidently the motor pinion should be made as small in diameter as practical, and the speed reduction between the pinion and driven gear a maximum. Light construction of the gear, using arms instead of solid webs, should be resorted to where feasible. High-strength material and wide-faced pinions permit using finer pitches with a resultant smaller pinion and gear diameter. The moment of inertia, being equal to the mass times the square of the radius of gyration, will be decreased correspondingly. An idea of the effect of the dimensions of a gear upon its moment of inertia can be gained from the fact that if all the dimensions of a gear are doubled its moment of inertia is multiplied 32 times. The same reasoning applies to the sprockets and pulleys in chain or belt drives.

Designing for a practical minimum moment of inertia of the moving elements of a machine becomes more important if the machine is to be stopped and started at frequent intervals. If the machine is to be reversed frequently, as in planer drives, the inertia will have a still greater effect upon the operation of the motor. This is particularly true when the motor is "plugged" into reverse. The motor then acts as a generator until it comes to rest, adding the voltage thus generated to the impressed voltage, the total causing a surge of high current through the motor. Unless properly designed to take care of this condition, the motor armature will burn out as a result of the excessive current.

In judging the severity of the duty upon the motor, a general rule to follow is that if the inertia of the driven parts equals that of the motor itself, the number of reversals per minute that the motor can stand will be reduced to one-half. Where reciprocating elements are involved, their equivalent moment of inertia should be calculated in order to make the comparison. As the linear

velocity V of the center of gravity of a rotating mass is $2 \pi R n$, we have:

$$\text{Equivalent } W R^2 = W \left(\frac{V}{2 \pi n} \right)^2$$

where

W = weight in lb. of the reciprocating part
V = velocity in ft. per min.
n = r.p.m. of the motor

Unless the calculations indicated above have been made, the designer is apt to be misled in over-rating the inertia effect of the reciprocating masses.

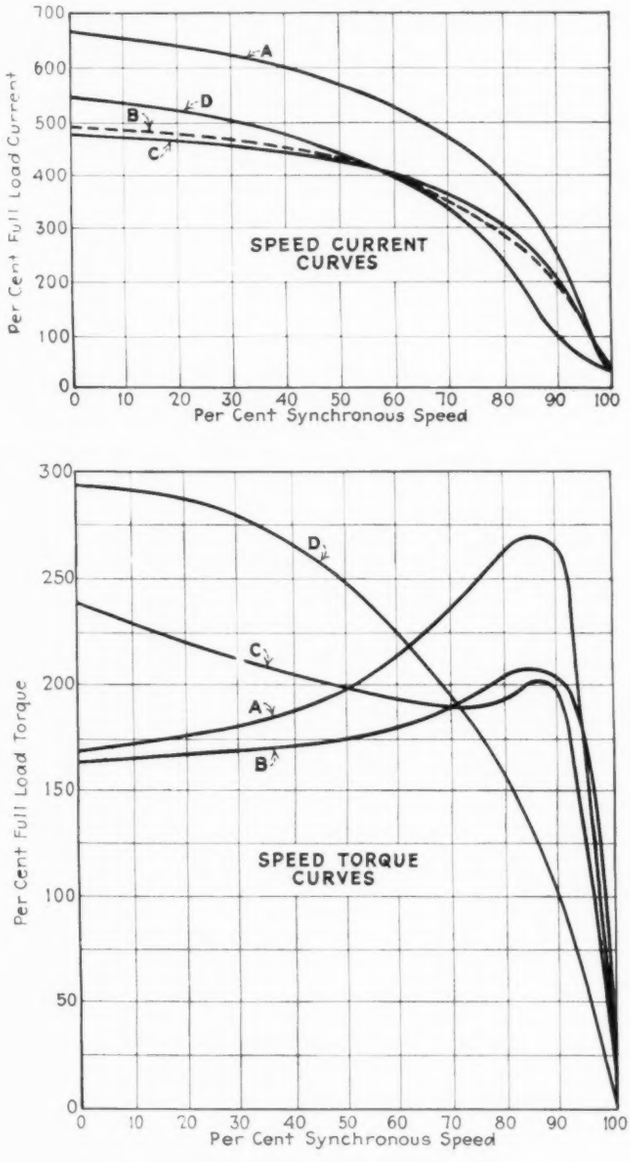
Machine tools, punch presses, ball mills, and other heavy machines, require high starting torque on account of the very nature of the machine. Special motors are available for such service. Thus there have been developed a.c. induction-type motors capable of delivering a high starting torque over a sufficient period of time to overcome the inertia resistance of the driven machine. Induction-type motors for this purpose have either a squirrel-cage rotor with fixed resistance or a wound rotor with resistance put in the motor circuit through slip rings and brushes. Whether fixed or external resistance is to be used depends upon the amount of heat to be dissipated.

GENERAL-PURPOSE induction motors have 3 to 5 per cent slip, but these special motors referred to have 10 to 12 per cent slip. It is this feature that allows the motor maximum time to overcome the inertia resistance. The effect upon the torque-speed characteristics of placing resistance in the rotor circuit is clearly shown by the accompanying curves.

Using general-purpose motors in applications where such special-purpose motors should be used is uneconomical. Thus, on account of the high starting torque involved, it may require a 3-hp. general-purpose motor to operate a punch press. Yet a 1½ hp. high-starting-torque motor would be more suitable. In one specific case a 45-hp. high-starting-torque motor replaced a 100-hp. general-purpose motor.

External revolving field synchronous motors have been developed for driving machines requiring an extremely large amount of energy to bring them up to speed. Such motors are called super-synchronous, and are used for driving line shafts, ball mills, and heavy machines. The rotor shaft is connected to the driven machine, and the stator is free to rotate. When starting, the stator frame rotates in a direction opposite to the normal field rotation. Full speed is reached quickly. The stator is phased in and the motor is then capable of developing its full pull-out torque, at unity or leading power factor. A band brake around the motor frame is then gradually tightened, either by hand or by an auxiliary motor. The rotor shaft exerts a rotating effort on the driven machine equally to the torque on the brake. Thus the driven machine is gradually brought up to speed, and, as the rotation of the motor frame slows down, the full torque is transferred to the driven machine.

Super-synchronous motors can be used only where slow starting is not detrimental to the purposes of the machine, and are not employed for power shovels and industrial equipment demand-



TORQUE-SPEED and current-speed curves for typical induction motors with various types of squirrel-cage windings. Type *A* is a standard squirrel-cage motor having normal starting torque and starting current, type *B* has a slightly lower starting torque but considerably lower starting current. The type *C* has lower starting current and much higher starting torque. Type *D* has the highest secondary resistance, resulting in a high slip, high-starting-torque motor

ing rapid manipulation. Moreover, their motors must be capable of speed control from zero to maximum, and for such service, the d.c. motor is better suited.

Speed control, usually limited to a high speed of about four times the low speed, can be obtained with d.c. motors by varying the resistance in the field circuit, thus changing the flux. The motor torque drops with increasing speed. Unlimited speed controls in either direction of rotation between zero and maximum can be obtained by varying the voltage impressed upon the motor. This last can be accomplished by field control of the d.c. generator furnishing the current, thus varying the voltage impressed upon the motor, and is known as generator-control or the Ward Leonard system. A separate generator is required for each motor that is to be controlled but the generators have one common driving motor.

This system has other distinct advantages in addition to the flexible speed control. Thus, the motor speed, since its field is separately excited, remains practically constant for a given setting regardless of the load; resistance losses are practically eliminated; and if the load is overhauling the motor operates automatically as a brake. The motors operate at a high efficiency at all loads. The field of the d.c. generator is excited by a low current, only about five amperes, hence no difficulties are involved in providing a large number of speed points. There is another distinct advantage in this type of control in that a series field can be used to buck the windings of the shunt field. This "differential winding" in the generator field causes a high motor load to cut down the generator voltage, reducing the motor speed and consequently its load. Thus, the current in the circuit is restricted automatically, and automatic self-protection is given to the whole electrical system. No overload protection is necessary. By reversing the generator field current, the voltage and motor rotation are reversed.

IN the application of generator-controlled motors to a power shovel, each motor has its own generator to furnish the current. This permits all the motors to be operated independently. In a complete installation, an a.c. motor drives three d.c. generators. To gain compactness, the motor-generator shaft may be designed to have only two bearings. A deep mounting base prevents weaving. One motor controls the rotation or "swing" of the super-structure of the shovel, another, the "hoist," raises and lowers the boom, and the third, the "crowd," drives the dipper.

Specify Scalped Cakes

By Paul B. Swinton

ENGINEERING specifications of materials are usually confined to physical characteristics and chemical composition. There are instances, however, wherein a detail step in the production of the material may have a very decided effect upon the product fabricated from it. The "grain" in rolled brass is one example. But the most interesting illustration of such situations was told to me by Ed. Mills of the Copper Products Company.

"We were building copper tanks designed to operate under 25-lb. pressure," he related. "The joints were brazed, and in the shop tests the brazed seams started to split open. Of course, we blamed it on improper brazing, and so it was, in a way.

"The shop conducted all kinds of experiments and tests, trying out different brazing methods. Results were extremely erratic; some good, some bad. Frankly, we were just stewing around getting nowhere when I spoke about it to Wilson, metallurgist for a copper company.

"He didn't even hesitate in making his answer. This is how he explained it: The flat cake from which they roll the copper sheet has a heavy oxide film on its upper surface. The oxide is of course rolled out into a film on the sheet. If one happens to use that side of the sheet, brazing reduces the oxide into a spongy weakly-adhering mass. Hence the failure. Some copper is rolled from 'wedge cakes,' the point of the wedge being the bottom of the mold. When the wedge cake is rolled out the oxide film is confined to the edge of the sheet. Of late the copper companies have been scalping the flat cakes, that is, planing off the oxide surface.

"If you intend using brazed joints in copper sheets, specify that the sheets are to be rolled from scalped cakes."

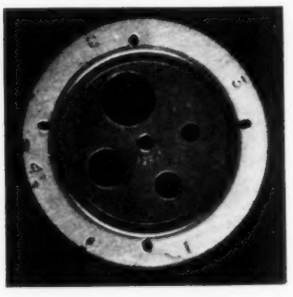
The erratic test results obtained in experimenting on the brazing can be explained by the fact that when the unoxidized surfaces of the two sheets were brought together for brazing, a good joint resulted. If the surface of one of the sheets was the oxidized surface, a weak joint would result.

Undoubtedly, many other similar instances can be brought to mind wherein some apparently insignificant detail in the production of the material has resulted in complicating matters or caused defects in the finished article.

FORMED nameplates, ornamental metal boxes, carton edging, clock faces, and camera parts are examples of the use of flexible lacquers in all colors

LACQUERS for Stamped and Formed Parts

By
LEO ROON
Technical Director, Roxalin Flexible Lacquer Company, Inc.



SINCE 1923, when the quick-drying nitrocellulose lacquers began to gain favor, especially in the automotive industry, much has been published on the subject of built-up lacquer finishes. It must be remembered immediately in this connection that on the automobile, refrigerator, typewriter, and similar products the lacquer finishes are built-up because the surfaces of the commodities are rough. Therefore, many layers of film-building materials must be applied and much labor expended to yield the delightfully smooth, eye-appealing surfaces demanded by the purchaser. Each year has brought forth novel

and interesting improvements in surfacing methods in order that sand holes and mold marks on castings, weld spots and grooves on sheet metal, file marks on bodies, and similar surface blemishes could be obliterated in the best manner in the shortest space of time, yet leaving a perfect foundation for the color coats to follow.

ON the other hand, little is written on the subject of nitro-cellulose lacquers in the finishing of products where the metal surfaces are extremely smooth and free from imperfections. Every engineer will readily admit that metal surfaces in this condition are an ideal foundation for a one-, or at most, a two-coat finish. He is then, of necessity, expected to require that nitro-cellulose lacquer to be applied on smooth metal have powerful adhesion and adequate flexibility so that the finish will "stay put." This discussion will, therefore, be confined particularly to the subject of smooth-surface lacquer finishing.

In his evaluation of nitro-cellulose finishing products, every engineer is committed definitely to the property of adhesion, regardless of whether the finishing material is to be applied on rigid objects or on those which will require flexing after the finish has been applied. However, the engineer does not always see that the property of flexibility is equally important. Flexibility, or in other words cohesiveness of the molecules of the finishing material, is of prime importance where the product will be flexed, but it is frequently contended that the property of flexibility is unimportant when the nitro-cellulose lacquer is applied on a permanently rigid surface. Considerable research and practical experience have indicated definitely that whether the final product is to be rigid or to be flexed, it is extremely necessary and desirable to have combined in the finished film, sufficient flexibility to prevent chipping and flaking, and sufficient adhesive force between the molecules of the finishing material and those of the metal surface to prevent peeling. Flexibility, however, must not be obtained at the sacrifice of toughness of film.

In order to make the discussion more specific, nitro-cellulose lacquers may be classified in four types. Type 1 lacquers have flexibility with toughness, but little adhesion. They have a high nitro-cellulose content, and high cohesive strength, but peel away from the edge of a sheared sheet, and will not stand assembly if the film is pierced by a tool. They are satisfactory if an adherent primer coat is used.

Type 2 lacquers have flexibility with softness and fair adhesion. The film is soft and "cheesy," and is easily removed with the finger nail. It prints and mars easily, and usually is a film over-plasticized in order to attain flexibility.

Type 3 lacquers have temporary flexibility and adhesion. They are satisfactory for certain operations if used at once, and resist chipping and peeling until sufficient plasticizer has been dissipated from the film to embrittle it. When this occurs, they chip and flake easily when struck, or break away when the metal is bent. These two types, however, are satisfactory where the surface is not subjected to bending or the action of blows.

Type 4 lacquers have permanent flexibility and adhesion. They will stand flexing until the metal breaks, will not lift from a sheared edge, will elongate with the metal when it is cupped, will not chip or flake in blow tests, and are unaffected by aging or accelerated brittling tests.

It is apparent that a nitro-cellulose lacquer of the latter type not only has considerable value in general application for smooth surfacing finishing, but fulfills also a specific demand in stamping and forming. This field was entirely held by the oleo-resinous products of the long-oil-varnish type. These lacquers which were developed some four years ago, are plasticized with plastic resins, and constitute an innovation which is meeting with wide application in many fields.

NITRO-CELLULOSE lacquers of the flexible type require no baking, and dry in the air in 15 minutes. With a temperature of 110 to 150 deg. F., however, the drying time can be accelerated to 5 minutes. They can be produced in any color, whereas the oleo-resinous products are limited to certain pigments. The cost of the lacquers is greater, but against this first cost, of course, must be weighed the value of speedier production and the color value.

The flexible type of lacquers find application to such products as: nameplates that are finished in the sheet and then formed; metal boxes, continuously finished in strip and later fabricated; camera parts; and also such articles as dolls' eyes, where a design is lacquered on the sheet and then blanked out and formed. For non-metallic products, such as those of rubber and wood, the lacquers are admirably adapted because of the ability to flex repeatedly. No one composition of lacquer, however, will suit all applications, and definite specifications must be in hand to fit a lacquer to the particular job.

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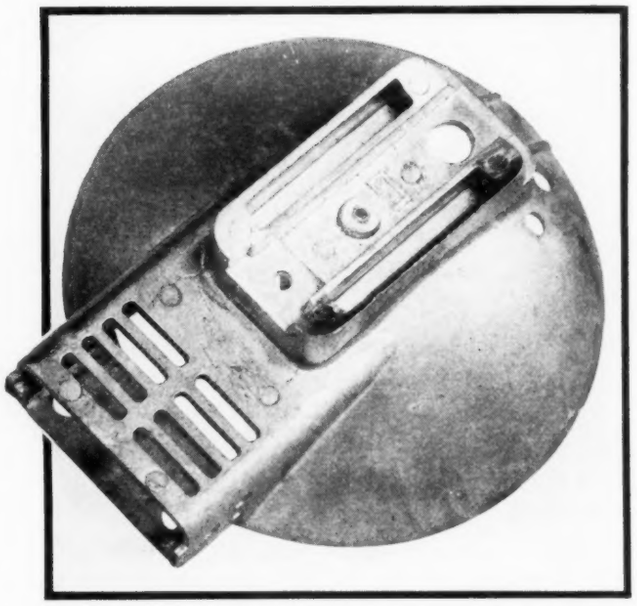


SURFACE appearances cannot give true indication of perfection or flows in this die-casting. The X-ray photo to the right proves it to be a sound casting.

WHY METALS FAIL

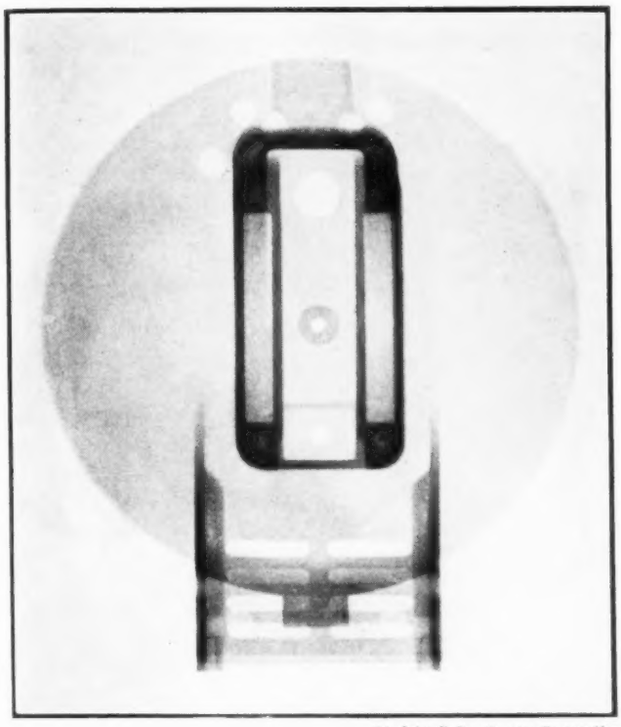
"A philosopher might truly say that the theory of elasticity is founded on false assumptions. Yet in spite of this fact it still works.... The metallurgical microscope and the X-ray spectroscope have profoundly modified our concept of how solid material acts under stress.... Our formulas for the strength of materials can no longer be looked upon as rigidly accurate, but they are statistically true and are safe."

DEVELOPMENT of our present-day formulas for strength of materials—both the common every-day formulas used by structural engineers and machine designers and the elaborate mathematical analyses used by students of the mathematical theory of elasticity—took place before the metallurgical microscope had shown the crystalline architecture of metals, and, of course, before the X-ray spectroscope had given us a convincing picture of the general scheme of the atomic structure of metals.

The fundamental methods of our modern elastic theory of stress and strain may be said to have been developed about 1824 by the French engineer Navier, a professor in the National School of Bridges and Roads. From the days of Democritus (about 400 B.C.) down to the days of Navier much speculative discussion about the atomic structure of matter took place. Nevertheless, from Navier to the present day, the formulas for elastic stress and strain have all been based on the assumption that solid material is continuous, indefinitely divisible without change of properties, and homogeneous. It is a rather curious fact that after the metallurgist with his microscope has shown that these assumptions are not rigidly true, the metallurgist himself still continues to talk about stresses and strains computed on the assumption that he is dealing with homogeneous, indefinitely divisible material. If the science of engineering materials had been in the hands of theologians or philosophers there might have resulted a period of bitter quarrel between the "atomists" and the "continuists," like the quarrels which centered round Galileo and Darwin. As a matter of fact the subject of strength of materials has been mainly in the hands of engineers. They have found that the formulas they have developed work fairly well, and have continued to use them without paying much attention to the truth of the assumptions on which they were based.

In 1845 Stokes, the British mathematician, published an article in which he quoted, as evidence of the truth of the assumptions underlying the theory of elasticity, the fact that the elastic distortions of measured specimens conformed to that theory.

If the theory of elasticity were true in a general "statistical" way for large numbers of crystals or fibers of solids we would still get *general* elastic distortions of bodies roughly in agreement with the behavior of a uniform continuous solid. However, Stokes' proof does not show that the *failure* of metal at *some localized spot* of weakness will follow the theory of elasticity based on the assumption of a continuous solid. Experimental proof of the truth of the theory of elasticity applied to the *failure* of solid bodies is very difficult, owing to the fact that the beginning of failure of most metals is not at all clearly marked. This failure may be of at least three types: (1) Inelastic action resulting in permanent distortion which may continue a few moments after application of the load but soon ceases to increase; (2) flow, as of a very viscous liquid, which is marked by permanent distortion which continues to increase as long as the load is applied, and (3) failure by actual fracture. Under repeated loading this third type of failure takes the form of a spreading crack. It is important to notice in considering the development of the theory of elasticity that elasticians have, in general, been interested in the problem of *deformation* of bodies, while structural engi-



St. John X-Ray Service Corporation

By H. F. MOORE

Research Professor of Engineering Materials
University of Illinois

neers and machine designers have been mainly interested in the problem of *failure* of metals at some region of maximum internal stress, or of minimum strength.

Any problem of machine design involving the strength of parts must answer at least two questions: (1) What are the loads which come on the part and what stresses do they set up in the part; and (2) what stresses will a material stand without failure? The first of these questions is answered by computation based on known service conditions, using the formulas of mechanics of materials. The second question can be answered only by actual tests of the material. These tests may be long-time service tests or laboratory tests.

The testing of the strength of materials is of ancient origin. A nearly crude method of test for brickwork consisted in seeing how long a cantilever beam of bricks, fastened together with mortar, could be constructed before it broke down. The application of test loads to bridges and buildings is very old indeed. A little after the time of Galileo special apparatus for testing strength of materials began to be devised, and the testing machine, consisting of some device for applying load to a specimen and some sort of a weighing scale for measuring the load on the specimen, gradually developed. The ordinary materials testing machine of today is much more accurate and much more convenient to handle than the testing machines of a hundred years ago, but embodies no principle which is essentially new. The development of special testing machines for making tests under thousands or millions of repetitions of stress, and for making tests under "impact" is an interesting story.

It might have been expected that the reliability of the elastic theory for predicting failure could have been very completely and satisfactorily checked by testing machine tests of specimens. Two difficulties limit this method of verification of theory. The first difficulty is the quite serious variability of quality even in our most uniform metals. Variations of 5 per cent in quality in different parts of the same steel bar are by no means unknown. The second difficulty was the fact that structural failure usually begins as a small localized failure and under a steady load cannot be detected until it has been progressed over some considerable area. Until recently the idea was commonly held that, for metals at least, there was an *absolute elastic limit* below which the material completely recovered shape after release of load, and above which there was a permanent set. The more careful the attempts to determine this absolute elastic limit the more elusive it becomes. Probably the *absolute* elastic limit must be regarded as an ideal quantity rather than an actual, although, of course, it is possible to establish for any metal an arbitrary limit for a *practical* elastic strength.

IN any event, the attempt to prove the validity of elastic formulas by detection of first inelastic action has not proved satisfactory. It should be noted, however, that direct experimentation with ordinary testing machines has been useful in developing the theory of the strength of columns.

The great field of usefulness of the testing machine has been in determining the stresses and strains which material will stand without serious damage, and in thus establishing criteria for acceptability of materials on the one hand, and, on the other, for determining and the limiting safe stresses to be used in formulas. Of recent years the possibility of using repeated stress tests and of tests of certain brittle materials to verify the formulas of strength of materials has been suggested, and gives some promise of usefulness.

Recent studies of the failure of metals under repeated stress (commonly, but rather inaccurately, called "fatigue" of metals) indicate that the theory of elasticity predicts probable damage to materials under loads somewhat smaller than those actually found necessary to do appreciable damage. This is especially true for the case of highly localized stresses, such as the stress at the root of a screw thread, the stress at a sharp shoulder on a shaft, the stress at the edge of a small hole. In this connection it should be noted that the ordinary formulas of strength of materials used by structural engineers and machine designers take no account of most of these localized stresses. We assume the stress at the root of a screw thread is equal to load divided by area of metal at the root of the thread. Actually the localized stress at the bottom of the thread groove is several times higher than this, probably three or four times higher. Localized stresses become of greater importance in brittle metals, and in all metals subjected to repeated stress.

The more elaborate formulas of the theory of the mathematical theory of elasticity can be used to compute some of these localized stresses (e.g., the stress at the edge of a small hole), and, as noted above, these formulas give results on the "safe" side.

When it becomes necessary to estimate a magnitude of localized stress, it is frequently found that even the theory of elasticity gives no usable formula for the computation required. In this case there are various mechanical methods of estimating such a stress. Perhaps the

most elegant form is the polarized light method. A specimen of transparent material viewed by polarized light changes color with change of stress. If, then, a specimen of simple shape is subjected to measured load until the color changes go through a complete cycle, the stress corresponding to such a complete cycle of color change can be determined. Then a specimen of complicated shape is stressed and the load necessary to cause a complete cycle of color change at any desired point is noted. Then the stress at that point is known, as is the change of load producing that stress, and, consequently the relation of load to the localized stress at that point. Various other mechanical methods of stress determination are in use.

EVER since members in structures and machines have failed in service people have observed the character of the fractures and noted the "grain" of the fractured material. It was in 1722 that Reaumur, the French mathematician and metallurgist, looked through a compound microscope at a polished piece of steel and reported that it was made of "flakes." From his day down to the middle of the nineteenth century the microscope was but very little used in the study of metals, when Sorby, taking the hint from the geologists' study of rocks, began to study metals through the microscope and started a method of test which has vastly increased our knowledge of the structure of metals. The microscope very soon disproved the notion that metals were homogeneous. It showed that all common metals were made up of crystalline grains, and that within these crystalline grains there were planes along which slipping of the metal took place easily, as is the case between the cards in a pack. Moreover, the microscope soon showed that the idea that metal "crystallized" under repeated stress had no evidence in its favor and that the danger under repeated stress was the spreading of a crack. The microscope also showed that both slipping and cracks took place fully as readily in the interior of a crystalline grain as they did at its boundaries.

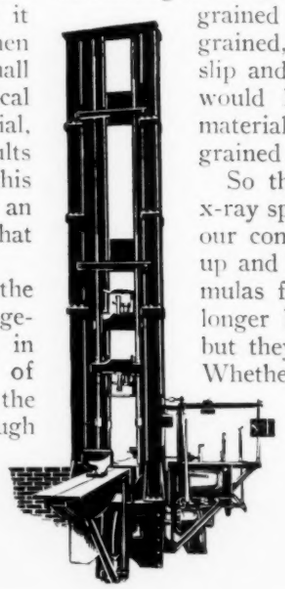
The significance of these discoveries through the microscope has not even yet been fully realized by the users of formulas for the strength of materials. Homogeneity and indefinite divisibility are obviously not true assumptions for actual metals. A philosopher might truly say that the theory of elasticity is founded on false assumptions. Yet in spite of this fact it still works, and works for two reasons: (1) Any aggregation of some thousands of crystalline grains acts "statistically" as if it were homogeneous and indefinitely divisible. (2) When we are forced to consider the strength of very small volumes of metal, volumes so small that this statistical behavior ceases to govern the strength of the material, then the formulas of the theory of elasticity give results which are on the safe side. To a pure scientist this second consideration would have no significance, but an engineer may, and sometimes must, use formulas that he knows are not rigidly true but which are safe.

A recent development in metallurgy is the use of the x-ray spectograph to determine the scheme of arrangement of atoms in a material. The wave length in x-rays is vastly shorter than the wave length of visible light, and is of a magnitude comparable to the spacing between atoms. If, then, x-rays are shot through a thin piece of metal, or are shot beneath the surface of metal, the directions in which some rays would find their path out of the metal would be determined by the spacing and pattern of the atoms in the metal.

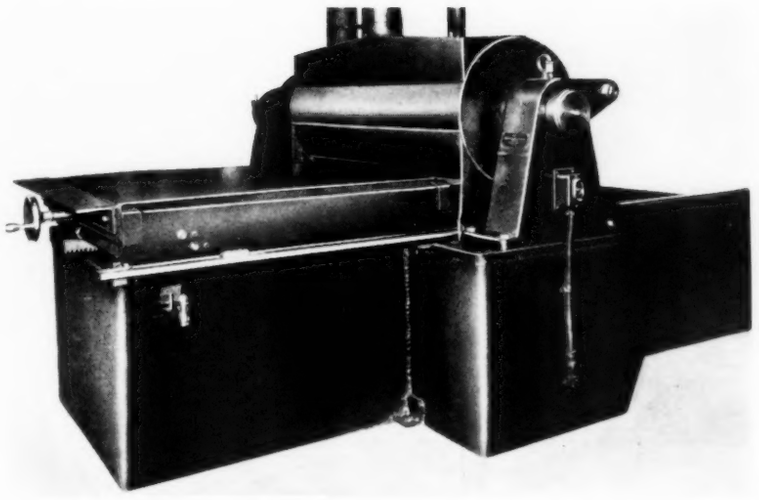
It is to be noted that the x-rays give us no information about irregularities in spacing of individual atoms in the space lattice, but only about their general plan of arrangement. Within a crystalline grain of metal, as shown by the microscope, the space lattice has a definite orientation. In adjacent crystals the pattern of the space lattice will be the same, but it will be orientated in a different direction. There has recently been developed the technique of formation of large crystals of metals, and a number of tests have been run of specimens made up of such single crystals. The results of these tests show that along the planes of atomic weakness these single crystals have extraordinary low strength. The failure does not seem to consist in the actual breaking of the bonds between atoms, but in the sliding of atoms along this plane of weakness, changing their bond partners as they slide. If this sliding is repeated, especially if it is kept up back and forth, cracks may develop due to wrinkling or other distortion along the plane of slip.

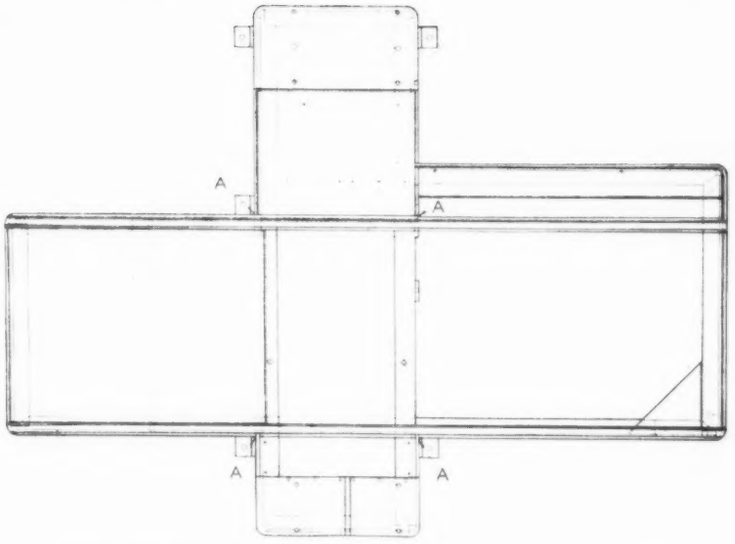
These tests of single crystals point out the possibility that the strength of our ordinary metals may be due, not so much to the cohesive strength of the bond between atoms, as to the interference to slipping which exists in a mass of variously orientated crystalline grains. In a single crystal there is nothing to stop this tendency to slip. In a multi-crystalline piece of metal the tendency to slip, or to crack, in any crystalline grain is blocked by adjacent grains. This is in agreement with the observed result that fine-grained metals have a higher elastic strength and a higher fatigue strength than do coarse-grained metals.

With the rapidly growing demand for metals to resist high temperatures the problem of strength of metals at high temperature becomes of great importance. The characteristic method of failure of metal at high temperature is a failure by flow, the metal acting like a very viscous liquid. Flow differs from slip in that slip soon stops even under a continuation of the load which causes it to start, while flow keeps on as long as the load acts. Flow simply takes place most readily at the grain boundaries of crystals where the atomic arrangement (the space lattice) is considerably disorganized in the transition from one crystalline grain to another. An interesting result of this fact is the observation that large-grained metals resist flow better than small grained, just the reverse of the resistance to slip and to fracture. Large-grained metals would have a lower percentage of their material in grain boundaries than small-grained metals.



So the metallurgical microscope and the x-ray spectroscope have profoundly modified our concept of how solid material is made up and how it acts under stress. Our formulas for the strength of materials can no longer be looked upon as rigidly accurate, but they are statistically true and are safe. Whether the theoretical cohesive strength of metals can ever be reached, seems rather doubtful.





THIS SPECIAL BUFFING MACHINE with welded base cost $800 less than one with equivalent cast construction. Plan view of buffing machine showing welded base of ⅝-in. plate with reinforcing members welded at *A*

Welded Construction

APPLIED TO SPECIAL MACHINERY

By D. V. WATERS

Development Engineer, Hawthorne Works, Western Electric Company

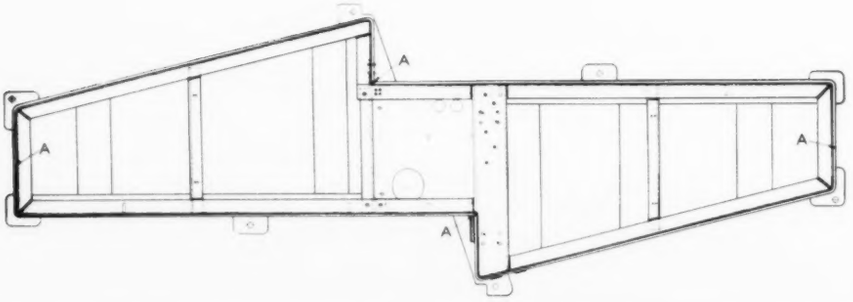
▼

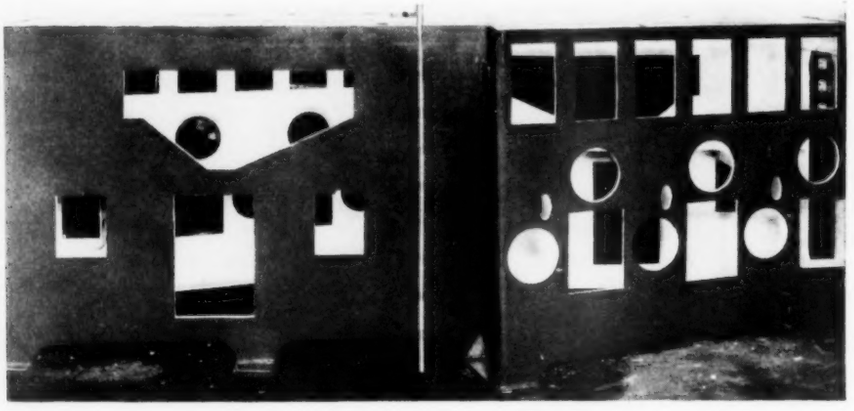
AS A RESULT of the development of acetylene and arc welding technique in recent years, welded steel construction in places where such construction was formerly deemed impracticable, is now used to good advantage. For some years past, the Western Electric Company has been developing welded steel constructions for many types of machines used in its production departments. Savings of both money and time in construction have resulted from the use of welded steel.

Good, sound, cast iron has an ultimate strength in tension of approximately 25,000 lb. per sq.in. and although it has no true elastic limit, the use of a figure of approximately 10,000 lb. per sq.in. involves no excessive error. An ultimate compressive strength of about 95,000 lb. per sq.in., an elastic limit in compression of 25,000 lb. per sq.in., and a modulus of elasticity of 13,000,000 are acceptable figures for average cast irons.

Mild steel containing approximately 0.15 per cent carbon has an ultimate strength in tension of about 63,000 lb. per sq.in. and an elastic limit of 35,000 lb. per sq.in. Its ultimate compressive strength is given as 55,000 lb. per sq.in. Although this apparently means that cast iron is superior to steel in compression, a higher factor of safety is necessary when cast iron is used. Hence, approximately equal compressive stresses are allowable for the two materials. The modulus of elasticity for mild steel is approximately 30,000,000.

Thus rolled steel is about three times as strong as cast iron in tension, resists compressive forces equally well, and has a stiffness 2¼ times as great. This does not mean, however, that full advantage should be taken of its superior physical qualities when substituting it for cast iron. for if machine parts made of rolled steel shapes or plates suitably welded were proportioned with only the unit stresses in mind (that is, so as to make the parts safe against failure), they probably would lack rigidity, as the various sections would be too thin, and the spacing of reinforcing members would not be adequate to prevent deformation under flexing





WIRE-TINNING MACHINE with base made principally from four plates bent to shape and welded at *A*. Base of wire-tinning machine, showing openings cut with a torch to accommodate various units

and comprehensive loads. Also, there would not be sufficient mass to absorb vibration. Therefore, it is often necessary to put extra material into steel structures to minimize distortion and vibration. This, of course, increases the safety factor.

Research work carried on during the past few years has resulted in producing more dependable cast iron and cast-iron alloys that are peculiarly suited for certain types of machine construction. Because of their cheapness, good machinability, fluidity when poured into a mold, and good bearing characteristics, they probably never will be displaced for certain machine members, particularly those incorporating sliding ways, gear boxes with intricate arrangements of bearing bosses and ribs, and the like.

For mechanisms such as machine tools, to be built in quantity and incorporating rather complicated units that require accurate mechanical alignment with other machine members, it is best to use cast constructions. Then pattern costs are not excessive and it is easier to secure the distinctive shapes and smooth rounded contours associated with this class of machinery. Also, it is sometimes advisable to use castings to build considerable mass into a machine to prevent vibration.

Many mechanisms, however, present real opportunities for the utilization of welded steel construction with its attendant advantages. Steel is the material "par excellence" from which to build large machines for which pattern and molding costs would be high; machines such as punches and shears, built to withstand definite and frequently-imposed stresses, and, in general, any machine the frame of which contains little mechanism, but that provides a base upon which the different machine units can be mounted. Cleaning, smoothing, and filling, which constitute no small part of the cost of each casting, are eliminated, as well as some departures from theoretical sizes, resulting from shrinkage, warpage, and similar causes. In some cases, considerable machine work is saved.

To use welded steel construction satisfactorily for large machine parts, a type of design quite different from that used with cast iron should be employed. When laying out such machine parts, consideration should be given to the applied loads in much the same way that a bridge truss is designed if maximum economy of material is to be secured. Standard rolled shapes, such as angles and channels, should be used wherever possible. Stiffening members of steel tubing or extra-heavy pipe welded in are excellent for withstanding torsional strains.

Straight lines and simple framing with few bearing bosses are of more importance than in an equivalent cast part, as the additional cost of a complicated structure is present in each machine instead of being "absorbed" in the cost of a pattern. As a guide to proportions that will give rigidity and reduce vibration, the "slenderness ratio" can be used profitably. This is the ratio of free length L to least radius of gyration R. The depth ratio for beams, L/D is also useful. Values of L/R not exceeding 90, and of L/D less than 10, will usually give satisfactory stiffness. For welded steel members subjected to exceptionally heavy shock loads, limits of 75 and 8, respectively, may be used.

Having determined the general outline and the

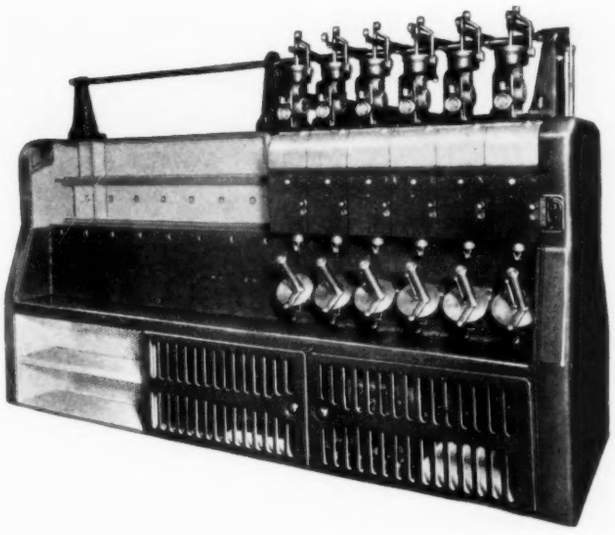
maximum loading which may be imposed upon a given machine frame or component part, its various members should be located so that, as far as possible, they constitute a triangular system of bracing. Load and reaction lines at a given junction, should be made to intersect at the same point so that the stresses are transmitted axially and do not set up twisting or bending moments. Sections should then be selected that will keep stresses and deformations within allowed limits, the members being placed with their gravity-axes coincident with existing force-lines. Sections should preferably be symmetrical, and when it is necessary to use unsymmetrical shapes, special attention should be given the end-connections to avoid complex stresses resulting from eccentric loading. In many cases the plate walls of a machine frame, with simple corner gussets and web stiffeners, provide all the strength and rigidity required.

End connections, of course, should be strong enough to permit the member to carry the kind and magnitude of load involved, be it compression, tension, flexure, torsion, or their combinations. The fillet-weld is the connection most commonly used in welded machine frames, athough butt-welds also are used to a considerable extent. A slightly reinforced butt-weld, if the weld-metal has the same properties as the base, in general will develop the full strength of the joined sections, due attention being paid to the stress localizations set up by the change in section caused by the weld-reinforcement. Fillet-welds in which ordinary structural steel parts are connected with weld-metal of corresponding quality can be loaded safely up to 1,000 lb. per linear in. for each $\frac{1}{8}$ in. of fillet. Safe loadings computed on this basis for fillets of various sizes, are shown in the accompanying table.

The loads given in the table are recommended by several companies based upon many tests by each. A series of tests conducted by the Western Electric Company showed ultimate strengths of from four to five times these loads. They correspond, therefore, to an allowed stress of 16,000 lb. per sq.in. in the parts joined by the weld.

In designing a welded connection the weld-metal should be so disposed that its center of gravity is as close as possible to the neutral axes of the members secured. Determination of the proper amount and distribution of weld-metal for both symmetrical and unsymmetrical sections loaded in different ways, cannot be dealt with here. Publications issued by manufacturers of welding equipment cover the subject quite thoroughly. In general, the method used is analogous to that employed to determine the number and location of rivets in riveted connections.

Suitable pads or bosses should be provided upon welded steel machine parts, just as on cast parts. These pads should be finished after fabrication is completed, so that different units will be aligned and secured upon accurately machined surfaces. No attempt should be made to assemble the different machine members upon rolled surfaces, and line them up by means of shims. Where a shaft projects through the walls of a welded steel machine member and is journaled therein, the best and cheapest construction is to bore an accurate hole through the wall, face-mill a pad on one side



FRAME and partly assembled machine for tinsel-serving. The driving motor and frequency changer are seen behind louvred doors. Cast end-housings cover unsightly parts and give a smooth contour

and bolt to it a flanged cartridge-type bearing that is a good fit in the hole. This bearing can incorporate oil seals, or odd-sized bores for anti-friction bearings, and is cheaply machined.

Accompanying illustrations show a special machine developed to buff the surfaces of copper plates used in the manufacture of phenol fiber sheet. To absorb satisfactorily the vibration produced by the heavy buff revolving at high speed, it was necessary to use heavy plates and internal bracing to provide the mass and rigidity necessary for smooth and quiet machine operation. The base of this machine consists, essentially, of four $\frac{5}{8}$ in. steel plates each of which is bent to form three sides of a parallelogram. By forming the walls of the base in this way, generously rounded outer corners are easily secured, and the welding, as shown at *A*, becomes relatively inconspicuous.

Table Showing Allowable Loads on Fillet Welds

Size of Fillet, in.	Allowed Load Lb. per linear in.
$\frac{1}{4} \times \frac{1}{4}$	2,000
$\frac{5}{16} \times \frac{5}{16}$	2,500
$\frac{3}{8} \times \frac{3}{8}$	3,000
$\frac{1}{2} \times \frac{1}{2}$	4,000
$\frac{5}{8} \times \frac{5}{8}$	5,000
$\frac{3}{4} \times \frac{3}{4}$	6,000

AMPLE bracing, composed of angles and channels sheared and welded to the outer walls at strategic points, is provided, and the ways upon which the reciprocating table moves are made of rectangular cold-drawn steel bars welded in place. The pads upon which the buffing wheel bearings are located and the table ways, were planed after fabrication of the base. Openings cut in the side walls with a torch afford access to the mechanism. The use of a fabricated steel base for this machine saved approximately $800 over an equivalent cast construction.

Other illustrations show a copper-wire tinning machine incorporating a welded steel frame composed principally of four plates bent to shape and welded at joints marked *A*. Generously rounded outer corners were provided and the welding is not particularly noticeable. Various openings cut in the side walls of this machine accommodate different units, and the feet are welded in place. The holes, the feet, and the lower contour of the frame are cut out with a torch. Bracing, composed of rolled shapes cut to length, is welded in place, and the entire frame is characterized by smooth contours and a neat appearance. A substantial saving was realized by the use of welded steel in this machine.

IN THE tinsel-serving machine shown the problem was to design a steel frame that would provide a rigid mounting for the individual serving units, inclose the frequency changer and distributor units, and present a reasonably good appearance. The motor and frequency changers are housed behind the louvered doors, and the shelves near the floor serve for the storage of spare spools. This machine frame incorporates light castings made to cover up moving parts and electric wiring at the ends of the frames, and to provide the smooth contour and finish that would be difficult to secure with welded steel end plates. The simplicity and economy secured are clearly evident. There is more space behind the serving heads available for the installation of electric wiring than with an equivalent cast construction. The saving resulting from welded steel construction, on a basis of sixteen machines in each manufacturing lot, is conservatively estimated at $450 per machine.

Examples cited make it evident that each machine should be separately considered when determining whether welded steel or cast construction should be used. The success of welded steel construction depends largely upon the skill and operating technique used in fabricating, and the availability of this must be considered by the designer.

In the past, many designing engineers have been very reluctant to use welded construction. This can be attributed only partly to the natural conservatism against venturing into new fields. The main reason was that the engineers could not feel certain that the fabrication of their welded design would be done properly.

Plates should be sized accurately, and before welding should be precisely located and clamped. Parts should be tack-welded together before final welding to allow for the effect of localized heat in the latter operation. Unless properly done by competent men, poor welds that will not withstand racking or vibration are likely to jeopardize satisfactory performance of the machine.

In general, when planning the design of welded machines, types of construction which cannot be produced satisfactorily or economically by the personnel and technique available should be avoided. Naturally, a sheet metal shop with well trained welders is likely to produce better work than one experienced chiefly with castings.

SILVERY PLATINGS

Where the Color Counts

By HAROLD WHITEHEAD
Baker & Company, Inc.

PLATING of metals to achieve better color and corrosion resistance has been employed for many years, but until recently the search for a silver-like finish has not been entirely rewarded. As compared with silver, nickel has a bluish tinge and chromium a purple cast. The latter metal is now well established for use on commercial products of many kinds and has mainly superseded nickel, but for some purposes it has been open to objection because of its color, and because chromium platings are likely to be porous and thus permit corrosion beneath the plate. Recently, an attempt to produce a white plate has prompted the co-deposition of nickel and cobalt, as noted on page 517 of *Product Engineering* for November, 1930. In all cases, however, imitation of a silver finish has been done with "base" metals, and the true color of silver has only been approximated.

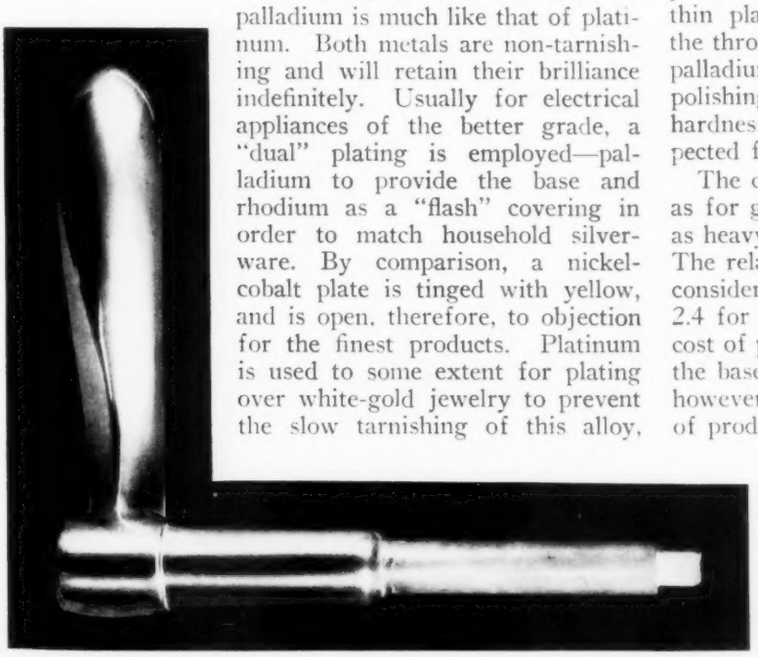
Recent technical advances in the handling of the "noble" metals have made practicable the commercial plating of palladium and rhodium, especially for such products as jewelry, silverware, household appliances of the better grade, hardware on custom-built automobiles, and high-grade watch movements.

Rhodium is a white metal, and is indistinguishable from silver, whereas the color of palladium is much like that of platinum. Both metals are non-tarnishing and will retain their brilliance indefinitely. Usually for electrical appliances of the better grade, a "dual" plating is employed—palladium to provide the base and rhodium as a "flash" covering in order to match household silverware. By comparison, a nickel-cobalt plate is tinged with yellow, and is open, therefore, to objection for the finest products. Platinum is used to some extent for plating over white-gold jewelry to prevent the slow tarnishing of this alloy, but is not commercially feasible for metal products because it is higher in cost than rhodium and does not have as white a color.

Resistance to oxidation of rhodium at practically all temperatures up to its melting point of 3,542 deg. F. has suggested its use as a plating on electrodes for spark plugs. Transitory oxides may be formed, but they are stable only within narrow ranges of temperature. Formerly, electrical contacts were made extensively of platinum, but have been displaced to an extent by base-metal alloys. Now, however, rhodium will probably find extensive use as a plating on such electrical parts.

IN the electrolytic deposition of the noble metals, either a "flash" coating or a heavy deposit may be employed, dependent upon the character of the base metal used for the part. For a flash coating it may be necessary to apply preliminary platings of copper and nickel. The "throwing power" of rhodium and palladium is excellent, making possible the plating of difficult shapes having re-entrant angles. If the surface to be plated is highly polished, the resultant plate will be even and of a highly reflective surface, requiring no finishing. If a matte surface has been left on the object, the plating will reproduce it exactly with the further advantage that no corrosion can take place. Fine etching lines on ornamental products will reproduce exactly, because on these only thin platings are ordinarily required, and because of the throwing power of the plating solutions. Since both palladium and rhodium are removed with great difficulty, polishing is done on the original surface. This great hardness indicates the wear resistance that may be expected for products subjected to much handling.

The cost of plating with palladium is about the same as for gold with the same thickness, since gold is twice as heavy as palladium and costs about one-half as much. The relative cost of plating with platinum-group metals, considering the cost of palladium as 1, is approximately 2.4 for rhodium and 2.75 for platinum. Of course, the cost of plating with the "rare metals" is higher than with the base metals. Such thin coatings are found suitable, however, that they do not add materially to the total cost of products of the better grade.



Die-cast door handle for a custom-built automobile, which has been base-metal plated, polished, and finished in palladium-rhodium plate. A silvery color with high wear resistance is attained

COMMENT AND SUGGESTION

40,000 Pictures a Second

By Fred H. Colvin

ANALYZING rapid motion by the use of slow-motion cameras has been tried many times. By the usual methods, however, it is necessary to stop the film at each exposure so that about 250 pictures per second seem to be the limit by this method. Beyond this speed, too, the lighting of the object becomes a serious difficulty. High-frequency, periodic sparks have been used, but are not easily handled. The method of using a constant source of light and catching the photographic impressions on a continuously running film by means of rotating mirrors or special prisms was adopted by Prof. Toyotaro Suhara, of the Tokyo Imperial University, with the result that he has taken 40,500 photographs per second.

The ultra-speed cameras developed are interesting pieces of mechanism. The first one, with which 2,000 pictures a second were secured, is shown in Fig. 1. Here A is a revolving reflector with 120 faces or mirrors. The film is wound on the drum D, both turning as shown by the arrows. The image G comes through the lens L and is reflected by the mirror face R to the film at M. Through the gearing shown both drums revolve at the same surface speed, each revolution of the reflecting mirror making 120 exposures on the film.

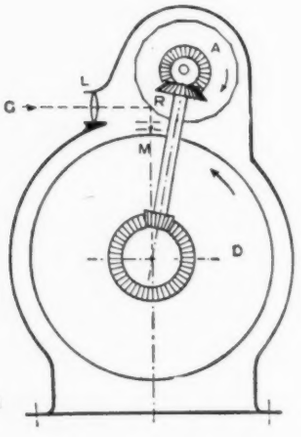


Fig. 1

Camera mechanism designed for 20,000 pictures per second

In the latest machine, Fig. 2, the revolving mirror is replaced by a polygonal pyramid A, of 180 sides, this being made of stainless steel and highly polished to act as a reflecting mirror. The film F is on the inside of the drum at D. The action is similar to Fig. 1, the two drums revolving at the same surface speed, each of the 180 facets on A reflecting the image on the film as indicated by the arrow that goes through the lens. Here each revolution of the mirror leaves 180 photographic impressions on the film. At the maximum speed of 230 revolutions per second this gives 41,400 exposures on the film.

A special automatic shutter closes the lens after one revolution of the main drum to prevent double exposure. The film is 4 meters, or a trifle over 13 ft. in length, and can receive about 1,000 photographic impressions. This utilization of revolving mirrors should have other applications in which rapidly successive images may be required.

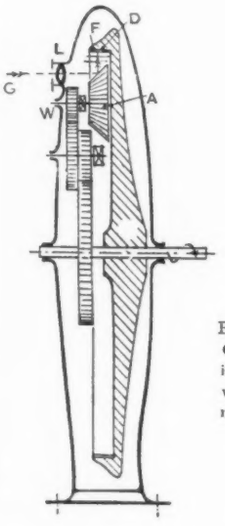


Fig. 2
Camera mechanism improved with steel mirrors, which double the speed

STOP . . . LOOK . . . LISTEN . . .

. . . SHOP CONTACTS . . .

SHOP contact for the engineer is always a troublesome business. The Seaman Body plant in Milwaukee seems to have solved it with what might be called a "liaison officer" in the person of the chief tool designer. The tool designer is the man responsible for producing something that permits the production department to make the parts which the product engineer designs, and if he has the personality to get along equally well with delving engineers and high-powered shop executives, the scheme ought to work.

. . . "ROMAN OF YESTERDAY" . . .

THE Colonel's Lady and Judy O'Grady are still sisters. And we moderns are still brothers to the ancient mound builders—at least if we may credit the designers of one new product. They offer a bronze-capped tube, 3 in. in diameter by 7 in. long, in which an individual may place a record of his words and deeds, the assembly to be buried with him. Pen, ink, parchment, and sealing compound are included, and the product is designed to withstand great pressure, weight, and corrosion. No heat-resistant properties are claimed. The idea is good, but the designer failed to incorporate a lie detector, probably figuring that where the user was going there'd be someone to judge the truth of his statements.

CAST OR WELDED

WELDED parts and complete machines are seeing wider use today than ever before, but it does not follow, by any means, that the casting has been outmoded or lost its value. Alloy iron

Who's Who?

By T. E. Jarnigan

JAMES A. COVINGTON, on page 79 of *Product Engineering* for February, deplores the presence of the names of engineers in previous volumes of "Who's Who in Engineering" "whose contributions to the engineering profession do not warrant their inclusion, in the opinion of many engineers." May I ask, simply, who are these "engineers" who consider themselves capable of deciding the comparative status of their fellows? The committee of the American Engineering Council appointed to assist in the work seems to me to include a number of men who are considered pre-emininent in engineering circles, and whose names are men-

tioned in every compilation of leading engineers. If they are not capable of judging who deserves inclusion, who can be found that could decide more capably?

Many self-styled engineers are of the type who say, "Oh yes, water—that's two atoms of hydrogen to one of oxygen, which, dissociated, forms—" and so on. They lose sight of the fact that water is also cloud, ice, rain, waterfall, cataract, rainbow, and raging torrent. These individuals are those who condemn all who do not share their own narrow conception of engineering. To them an engineer is an individual who carries a certain number of engineering degrees, who has spent a certain number of years in a design room, who has a certain number of patents, or who has presented a certain number of papers before engineering societies. They forget that many men can be considered in these classifications who do not—or could not—lay any claim to the title of engineer. They forget that practical men may also be engineers, that many men well worthy of the name "engineer" never attended an engineering institution nor presented a paper. Who is to judge these men better than the above-named committee?

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More Rubber in Machines

ONE well known automobile has in its structure no less than 270 rubber parts, forming 3.8 per cent of the weight and 3 per cent of the cost of the car. Out of the total of 141 lb. of rubber 38 lb. are in so-called "mechanical" parts. Here is ample evidence that rubber is a valuable machine element.

Rubber is used not only because it is an excellent cushion, acting to absorb unpleasant vibrations and to prevent their transmittal from part to part, but is employed also to bush spring shackles and shock absorber links, the rubber being distorted by the torsion or rocking action. There is, however, no sliding action between either rubber or metal parts, and consequently no lubrication is required. The loading and character of rubber used is said to be such that the bushings will last for the life of the car.

These are important facts, for they seem likely to mean that rubber can be used to advantage at oscillating or rocking bearings on many machines to eliminate wear and to make lubrication unnecessary.

and steel castings and even gray and malleable iron possess useful properties not available in wrought metal. Moreover, there are numerous cases, especially of complex parts produced in quantity, in which ordinary cast metals may never be displaced.

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. . . SELF-WIPING WINDSHIELDS? . . .

"WHEN shatter-proof glass is made upon a frame, it might be possible to inject into the materials of the frame a conductor of electricity which would provide, by proper electrical connections, enough heat so that the whole of every automobile windshield and every window can be kept clean of rain and sleet." This is a statement made by Robbins B. Stoeckel, Commissioner of Motor Vehicles, Connecticut, in a paper presented at an S.A.E. meeting. There is nothing too far-fetched in the idea; he points out a possible future development.

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. . . RARE METALS . . .

EVERY treatise on the rare metals lists rhodium as too rare an element for commercial use. Small amounts of rhodium-platinum have been employed for resistance furnace windings, but rhodium wire and sheet still remain only laboratory products. However, one company apparently is determined to turn the high hardness and beautiful white color of this metal to commercial use. On another page is told how rhodium is being used successfuly as a plating metal. It doesn't take much metal to plate a waffle iron or a percolator, and see the effect! Good luck to them!

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. . . AWAY WITH ELBOW GREASE . . .

GASOLINE filling station pumps have gone through a continuous development. A few years ago motorized pumps, using explosion-proof motors, were put on the market. It seems that last year none of these were "sold"; it was merely a matter of taking the orders. One manufacturer marketed $500,000 worth of motors for these pumps, an example of the results obtainable from product engineering.

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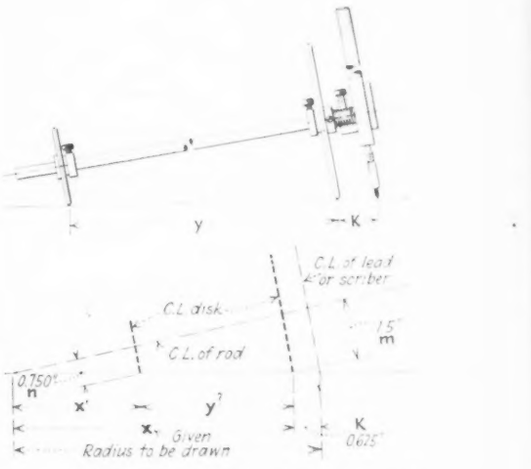
. . . FORWARD BUT BEHIND . . .

FORWARD-LOOKING automotive engineers now are glancing behind, so to say, because the idea of cars with engines in the rear, as mentioned frequently in this column, has caught their fancy and was much discussed at the recent annual S.A.E. meeting, though not officially on the program. Buses with engines at the rear are already in the making, and it is probable that experimental cars with such an arrangement will be found before this year ends.

A Tool for Drawing Large Radii

By Henry W. Boehly
Machine Designer, Mergenthaler Linotype Company

IT IS not unusual in the drawing room or shop to have a problem come up requiring the drawing of large radii. Trammels are not always at hand, or are not always suitable, and the old-time string method lacks in accuracy. The accompanying tool



Mechanism for drawing large radii and diagram used in calculating the setting

may be a simple solution for this type of work. It is based on the geometric theorem which reads, "Two right triangles are similar if an acute angle of one is equal to an acute angle of the other." The tool should be designed to suit the size of radii most frequently occurring, or two or more sets of disks may be made to enlarge its capacity.

Construction of the unit is evident from the drawing. The lead holder is a slide fit in the adjustable housing which may also be locked with a setscrew. Calculation of the required distance between the disks in order to draw an arc of given radius is simple. Assuming that the diameters of the smaller and larger disks are $1\frac{1}{2}$ and 3 in. respectively, it is required to draw a 22-in. radius. Distance K is assumed to be $\frac{5}{8}$ in. Then in the sketch;

$$X = 22\text{-}K = 21.375 \text{ in.}$$
$$m = 1.5 \text{ in.}$$
$$n = 0.75 \text{ in.}$$

then $X : X' = m : n$

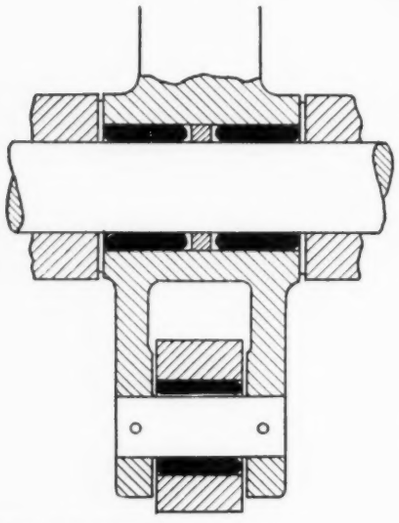
$21.375 : X' = 1.5 : 0.75$

$$X' = 10.6875 \text{ in.}$$
$$Y = 21.375 - 10.6875 = 10.6875 \text{ in.}$$

required to draw the desired arc.

Needle Bearings Developed in Europe

A PROMISING and interesting development of so-called "needle" bearings has been under way in Europe for several years. Although resembling a roller bearing, these bearings use rollers of very small diameter, have no cages, and often

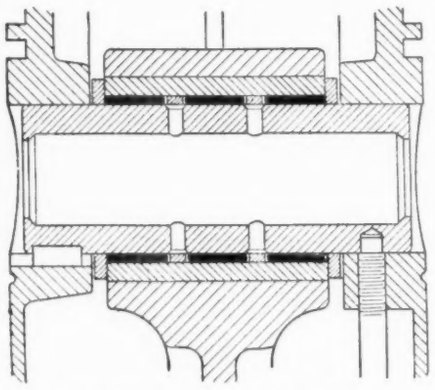


Needle bearing arrangement on a rocker arm

are made without separate races, the rollers being placed in contact with the hardened shaft on one side and the bearing bore on the other.

As described by M. Pitner in a paper before the French Society of Automobile Engineers, the bearing acts somewhat like a floating bushing. Except in starting, when the rollers are in mechanical contact with the raceways, the rollers do not turn on their own axis but, in effect, float inside a thick oil film which surrounds them on all sides. Although the shearing force of the film between the rollers and raceways tends to cause rotation of the rollers, a greater force, caused by the friction of the rolls against the prisms of oil between them and contacting with the greater part of their circumference, prevents this rotation.

According to the paper, the oil forms a cushion which resists shock. The film also prevents skewing of the needles or rollers, such skewing in an ordinary roller bearing without cages being the result of sliding metal-to-metal friction. Needles are made in diameters 0.08 to 0.16 in., have rounded ends, and are given minimum



Piston pin needle bearing with three rows of rollers

end play, between shoulders, of 0.002 in. It is reported that piston pin loads as high as 7,800 lb. per sq.in. have been carried on such bearings, and that loads as high as 3,400 lb. per sq.in. are carried regularly at speeds as high as 5,000 to 8,000 r.p.m. Bearings split in a plane through the axis, as on crankpins, are used satisfactorily if provision is made for keeping the cap true with the other half.

■

Decimal Dimensions

By Clarence J. Harter
Harter Educational & Engineering Service

THE man who works from a drawing on interchangeable work does not think in common fractions, but converts the common fraction to a decimal before using, this taking considerable time. To overcome the disadvantages of the fractional method for dimensioning drawings the decimal sub-division of the inch could be used. In the following outlined decimal system the degree of accuracy of each dimension is expressed by the number of decimal places to which the figures are carried out.

The decimal sub-division of the inch is used exclusively on all drawings excepting where standard sizes of drills, reamers, taps and screws are used. The reason for using common fractions here is to avoid confusion when calling for purchased parts if the articles are commercially listed in that way.

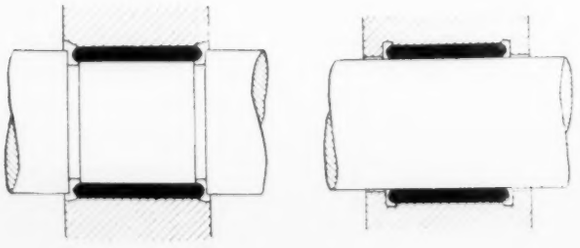
The limits of variation are indicated by the number of decimal places used, as follows:

Figures carried to one decimal place (.0) indicate that the total tolerance is 0.1 or ±0.05.

Figures carried to two decimal places (.00) indicate that the total tolerance is 0.01 or ±0.005.

Figures carried to three decimal places (.000) indicate that the total tolerance is 0.001 or ±0.0005.

Figures carried to four decimal places (.0000) indicate that the total tolerance is 0.0001 or ±0.00005.



Alternative arrangements of common needle bearings

■

Under the Plate

PLATING, as a process, concerns the production department more than the engineer, but designers certainly are interested in the results secured, and need to know something of the processes involved in order to prepare intelligent specifications for the finish.

Recent research has made it increasingly evident that preparation of the surface prior to plating has a most important effect upon the results produced. A chemically clean steel surface is a primary requisite for good plating. If oxide remains on the surface prior to grinding, the wheel is likely to grind part of it into rather off of the surface. And such oxide inclusions, though bridged over by the plate, form nuclii from which corrosion starts much sooner than it would begin otherwise.

Much scale can be removed by grinding, of course, but if a coarse abrasive is used, deep scratches result and the repeated grindings that must follow leave hills and valleys that disperse light and dim the polish even after plating.

One of the electrolytic cleaning processes recently developed not only gives a clean bright surface, but is said to remove oxides embedded in the surface as well as to reduce materially the time and the embrittlement incident to ordinary pickling. It is merely another indication that engineers need to keep abreast of modern improvements in production methods.

Non-Uniform Mechanical Feeding

By Charles F. Smith
Consulting Engineer

SOME years ago, I designed the variable feed mechanism illustrated below for the purpose of slacking up the feed of paper rolls when cutting off tubes in the manufacture of paper bags. Paper bags cannot be cut with what is known as a striker without slackness in the tube. After cutting, the speed has to be brought back to the original rate. Another use to which I have put such a feed is in conveying applications where a piece has to be gotten out of the way of the next piece, and still make but one revolution for the rest of the cycle of operations.

Referring to the accompanying figure, shaft *C* has an arm *D* fastened to it and carrying a bell crank segment gear *E*. This segment gear *E* is driven by a stationary cam or eccentric *F*, fastened to the frame or bracket. On the same shaft is a sleeve gear *G* that is loose on the shaft and driven by the bell crank gear *E*. A roll segment *H* is mounted on the sleeve *G*. Gear *I* for driving the upper roll *J* causes both rolls to move in unison. The cams or roll segments can be varied to meet any condition of movement required.

If only a portion of the revolution is needed, either for slow or above normal or constant speed, a roll segment can be used instead of a full roll, so that no action will take place except when the segment is in position and the controlling cam or eccentric is operating it. For example, if the movement required through 90 deg. is faster than the normal or constant speed, the cam should have throw enough to move the sleeve gear 90 deg. If the sleeve gear moves 90 deg., and the cam is laid out to operate at 90 deg., the segment roll will be caused to move through 180 deg. in the time required for the shaft to move through 90 deg.

When the full roll is used under the same conditions of action through 90 deg. and return for 90 deg., there would be left a dwell of 180 deg. On the return motion, the roll would lose 90 deg. while the driving shaft is is turning 90 deg., so that the roll would be back in its original position when the operating segment comes to the dwell. At this point, the speed is the same as that of the driving shaft. The cams can be varied to meet any condition or movement forward or backward.

■

Identifying Drawing Changes

By John F. Hardecker
Chief Draftsman,
Naval Aircraft Factory

SHOP men who deal with large crowded drawings, sometimes six to eight feet in length, often experience considerable difficulty and time loss in locating changes in the body of the drawing, indicated by witness numbers referring to change slips that accompany the drawing. There is also danger of overlooking some items when the particular drawing involves many changes.

A simple expedient used by a large airplane manufacturer, is to place additional witness numbers or letters along the upper margin outside the border line, directly above the corresponding point in the body of the drawing, after the method followed on maps to facilitate quick location of cities from corresponding index designation. The shop man merely follows along this upper border untill he finds the witness mark of the particular change. Below the mark, in the body of the drawing, he can quickly locate the changed dimension or detail.

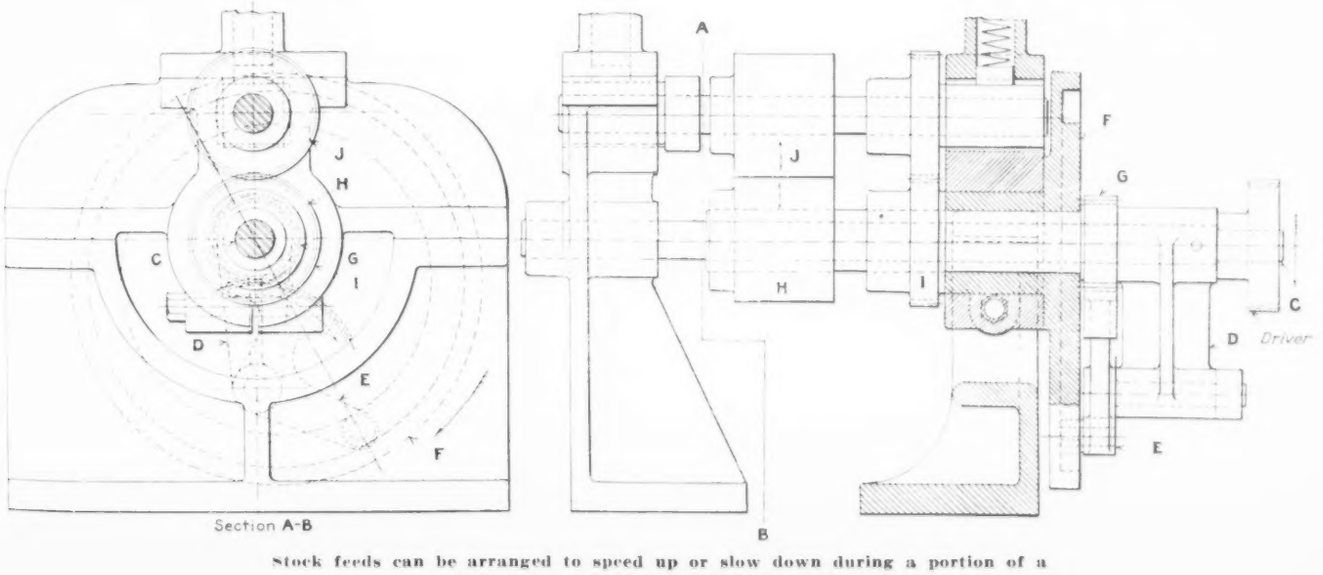
■

Stronger or Lighter?

By A. H. Steele

THAT time-worn expedient of merely adding weight to parts which have a habit of breaking in service is still resorted to by many engineers, doubtless with satisfactory results in many cases. Sometimes, however, a much better expedient is found by changing the design in such a way that the possible stress applied is so greatly reduced that the part actually can be made much lighter, with consequent reduction in cost.

A case in point is the frame of automobile chassis and bodies which have constantly been increased in weight to make them stiff enough to withstand twisting and other stresses. Fortunately, some engineers are now beginning to think about reducing the possible stresses on these structures by the simple expedient of mounting either the body or the chassis frame upon a three-point support. With such an arrangement twisting strains are greatly reduced and lighter structural members are feasible.



Stock feeds can be arranged to speed up or slow down during a portion of a cyle by means of this variable-feed mechanism

PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

April, 1931

. . . The engineer of today must not only be able to design an efficient machine, but he must be able to predict with a fair degree of accuracy the various economic results that will be attained . . .

—FRANK L. EIDMANN, *professor of mechanical engineering, Columbia University.*

Design It In!

MODERN product design calls for specialized parts and units, die castings, and molded parts to be procured from specialists who make the development and efficient output of them their special business. Thus, the designers and producers of the major product are considered to be left free to put their thoughts to work on the bigger problems of the machine. But this conclusion does not mean that the product designer should leave the incorporation of the unit as an afterthought to be simply "attached." He must give it prime consideration and design it in as a working part of his own product if best results are to be obtained.

The designer of a certain automatic vending machine intended to incorporate a counter on the machine—in fact, a counter was a necessary factor in the sales value of the machine. But he completed the design of his machine and got parts in production before he found that his "attachment" would not give satisfactory service. The counter engineers were called in and received the tale of woe. The answer was that the mechanism was attached in an improper place where it received full force of a heavy blow. It was too late to do anything, and there was endless trouble until a redesign could be made.

Again, machine designers sometimes express themselves as being unwilling to put themselves "at the mercy of the parts maker" by designing the part directly into the machine. This has happened more than once in the case of motors. No first-class product can be expected unless the designers consider in advance all operating functions of the machine. Let the engineers of the specialty manufacturers be treated as friendly consultants, and the results will show!

■

Co-operate for Quality Designers

COMPLAINTS have been made that engineering graduates have not been grounded sufficiently in the fundamentals of product design, that they have no appreciation of practical requirements and are unable to apply the principles they supposedly learned. Much of the criticism is unwarranted, some of it is justified.

Professors of machine design have long recognized that there is always room for improvement in the teaching of their subject. But there are many difficulties. Limited student's time, the necessity for co-ordinating the work with that in other departments, and the question of best teaching procedure, must all be given consideration. More important than these are questions as to the portions of the subject to be stressed.

As announced elsewhere in this number, teachers of machine design have formed a "clearing house" to exchange ideas and information of mutual interest. A concerted effort is evidently being made by the college professors to meet the demands of industry.

Engineers in charge of product design can help materially by volunteering their criticisms of college graduates, and expressing their opinions as to what should be emphasized in machine design courses. As David Ross, retired president of the Ross Gear and Tool Company and now president of the board of trustees of Purdue University, expressed it, "Why don't you men who are criticizing the colleges do what I did?"

It is not to be expected that every engineer can devote all of his time to college administration. But all can be of material assistance. Constructive criticism rendered in the right spirit would un-

doubtedly be welcome and of mutual benefit. What do executive designing engineers demand of the technical school graduate? Is it skilled drafting, knowledge of standard design practice, or a thorough grounding in applied mechanics and stress calculations? Tell the "profs"!

■

Too Cheap!

OUT of the radio industry comes a warning that can well be taken into account by product designers in other fields. Designs of low-priced radio sets have been cheapened in some cases to an extent where it is impossible to receive the full scale of music or the range of voices. Broadcasting has been improved so wonderfully, says *Radio Retailing,* that outside the listener's house the air may be filled with music of perfection of tone, but all that comes through to the owner of the "cheap" set is a short range of notes and distorted voices. The marvels of modern broadcasting are lost in these receivers.

No wonder radio is in a depression! The long-winded announcer of superlatives is apparently not the only reason why the radio is not used more. Perhaps some companies made sales by cheapening the product below the point of efficient operation, but, if so, will anything be gained in the long run? There should be a quality standard below which the designer of any product should not permit his product to fall. If a part of the market demands something cheaper, then it should be a thing apart—and so labeled by a cheap case, or otherwise, that it would not be detrimental to the sales of better-class products.

■

Painted With Adjectives

A CORRESPONDENT rises in his ire to say that the public has become exasperated by automobile manufacturers who "continue to offer the same old product from year to year but painted with every extravagant adjective that could be culled from the dictionary. The automobile industry," he adds, "is in need of some wise counsel, because it has clogged industrial and railroad enterprise by its approximate stagnation. . . . If there is power in the pen . . . editors should address pertinent editorials to engineers and executives in industry who are always looking backwards and are loath to believe their product is not perfection."

It is a significant fact that the automobile company responsible for certain of the most radical departures in design introduced in recent years is the only one whose stock is booming today and whose plants are working at full capacity to fill its orders. This company presented one of the most advanced designs at the show this year, and at the same time offered the new car at a price so attractive that sales have been phenomenal.

When competent and progressive engineers are given a reasonably free hand and are backed by executives with vision and a live sales organization, there is no need to paint the product with adjectives in order to sell it.

▼

New Designs for Old

COMPLETE REDESIGN is often claimed but seldom attained. Why does the resulting product often fail to attain the anticipated enthusiastic reception? Sometimes, imagination is lacking; usually, some vital single detail has been overlooked. More often than not, that detail is so established by custom and use that it is considered unsusceptible to improvement.

For example, have not housewives objected, from time immemorial, to the burner and grate arrangements on gas stoves because of the difficulty in cleaning them satisfactorily? Again, has not the usual first driving admonition been "Don't ride the clutch!"—certainly, that is a condemnation of the clutch design as well as a caution to the driver. Or still again, need all clock faces be flat, hence readable only from a limited angle, just because clock faces have always been that way? Finally, need coolant pumps on some machine tools be so inferior to the machines?

Redesign must take every product element into consideration, no matter how established by custom that element may be. New designs open new possibilities; only by utilizing each element to the full can redesign become a reality.

WHAT'S GOING ON—

Trends In Product Design

WELDED DRUMS for power boilers have been under discussion by the Boiler Code Committee of the A.S.M.E. The "Proposed Specifications for Fusion Welding," as printed in the March number of *Mechanical Engineering*, set forth proposed revisions now under the joint consideration of the American Welding Society and the Boiler Code Committee. The proposed code classifies pressure vessels in three classes, power boilers and vessels containing noxious, poisonous or inflammable liquids or gases, and two classes of vessels that do not contain dangerous liquids or gases. Four grades of welding are recognized. According to available information, several boiler manufacturers are already properly equipped and prepared to go ahead with the fusion welding of drums for power boilers, just as soon as the proposed code is authorized. In addition to its sweeping effect upon the design of fusion-welded drums for power boilers, the code will provide a distinct impetus for the more general application of welding to the immense and growing field of unfired pressure vessels. It is reasonable to suspect that many tanks and containers now designed for riveted construction will have to be redesigned for welded construction in order to keep abreast of competition.

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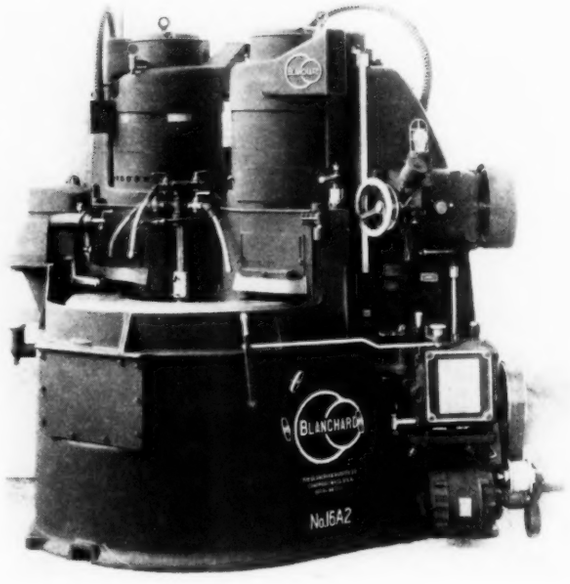
FRUIT JUICE shipping cans of 20-gal. capacity are now being deep-drawn in one piece from 17-gage chromium-nickel alloys and are supplied in three finishes: White pickled outside and polished inside; polished both outside and inside; and white pickled outside and inside. These cans have slightly rounded bottoms and are much easier to clean and keep sanitary than built-up cans. They also have high resistance to abrasions, indentations, and distortions likely to result from rough handling. Sizes other than 20-gal. capacity are being considered.

Two wheelheads, one roughing, one finishing, are mounted on the Blanchard No. 16-A2 automatic surface grinder. The roughing head wheel-control caliper may be so set that it will always leave the same amount to be removed by the finishing wheel. Seven motors are required for the machine, the base of which serves as a coolant tank and cleanout hopper



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TAMPERING with a precision ball-bearing lathe center of the Ready Tool Company is prevented by covering the clamp-nut locking set screw with a flush soft metal seal. The tool is guaranteed so long as the seal remains unbroken.

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A Glance Over the Pages—

1. *What materials are used for milk-handling apparatus? p. 150*
2. *Why must accurate parts of some aluminum-bronze alloys be made by precision die-casting or forging? p. 151*
3. *What is the common requirement in the design of all chain wheel tooth forms? p. 152*
4. *What is the general relationship between the dimensions of a wheel and its inertia? p. 159*
5. *What are the four distinct types of cellulose lacquers? p. 163*
6. *When did special apparatus for testing strength begin to develop? p. 165*
7. *How should weld metal in a joint be disposed with respect to the neutral axes of the members secured? p. 169*
8. *What are needle bearings? p. 174*
9. *How will streamlining help train design? p. 179*

•

FLEXIBILITY in models has been gained in the new line of Servel Hermetic refrigerators by the interchangeability of 3 bases and 3 compressor units. Fifteen models are available. The chilling unit is finished in white porcelain on steel, and the cabinet liner is white vitreous porcelain fused on rust-resisting steel. The exterior is Bonderited metal with white "Pyroxylin" finish. Hardware is heavy brass chromium plated with satin finish. Another refrigerator, announced in Chicago, incorporates a coin-operating device, by which the user pays for his refrigeration by inserting quarters. Incidentally, the present set-up of the unit gives 40 hours refrigeration per quarter, but the unit may be set to give a shorter period, thus permitting the user to purchase the machine on a part-payment basis.

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AN ALL-ALUMINUM truck for food transportation is being manufactured by the Service Caster & Truck Company. It follows conventional push truck design, is equipped with Hyatt roller bearings in all wheels, and a hardened steel double-row ball thrust bearing in the swivel of the rear caster.

GENERAL MOTORS and Mack are out with new models of buses intended to meet changing requirements of operators but involving few radical departures in design. Increased accessibility, lower upkeep expense, greater power per unit of weight, and more comfort for passengers are among the objectives said to be realized. Mack's latest "Street Car Bus," has the windshield brought forward to the radiator, the engine recessed into the body, and the driver's seat beside the engine. Thus room for 44 seated passengers is provided. At least one bus manufacturer has an experimental model with the powerplant placed in the rear. Some German trucks are streamlined.

FORD has introduced new body models with sloping windshields and a 2-in. increase in length, but only minor refinements in the chassis.

DUPONT'S automobile color index lists black, blue, brown and green in this order of popularity in February. A year ago the order read: brown, blue, green, black.

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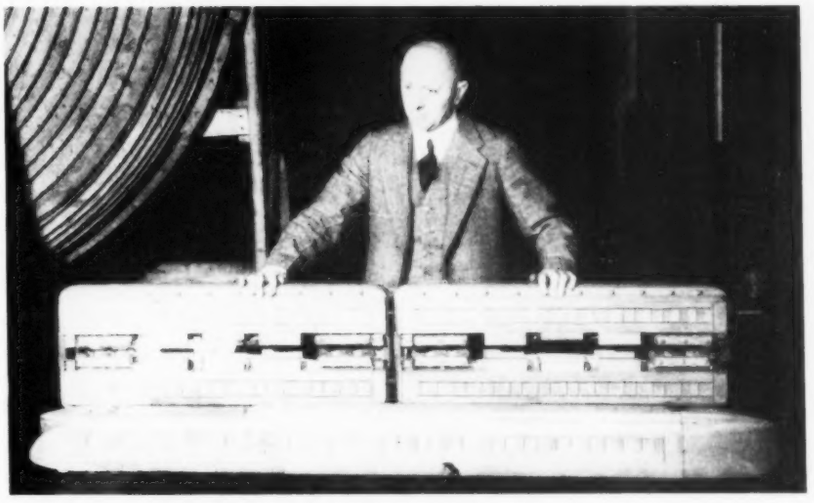
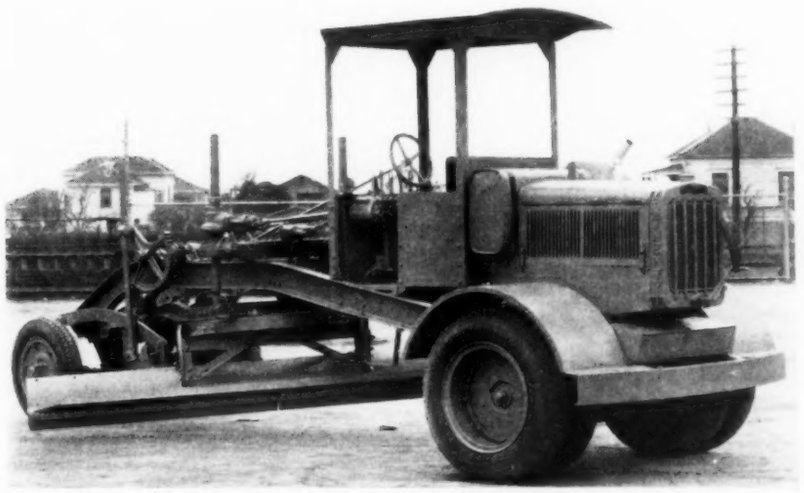
POSSIBILITY of a change in a 70-year-old mechanism is indicated in the invention of a turret-type controlled roller for window shades. When released the roller maintains a silent slow-winding action until the shade cloth is wound up. A micrometer screw then slows down the mechanism and an automatic stop brings it to a standstill. This same stop acts as the lock to hold the shade from slipping. Rustless metals are used throughout. Patents are held by B. Edward Mesler.



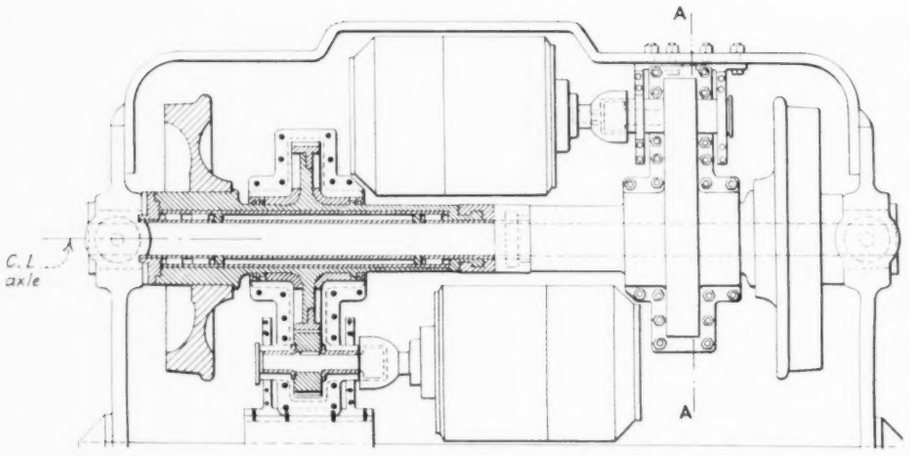
A FALLING drop of water was taken as the basis for the high-speed train designs of Dr. Oscar Tietjens, Westinghouse research engineer. He expects streamline design to cut wind resistance two-thirds and lower power consumption one-third at 80 m.p.h.

FLEXIBLE MIRRORS are being made by a "Metal mist" process at the California Institute of Technology. The mirrorlike surface can be laid upon metal, cloth, paper, rubber, or nitrocellulose membrances, the surface being of gold, silver, copper, or chromium—in fact, any ordinary metal, and such non-metals as quartz, fluorite, and silver chloride. The process, developed by Hawley Cartwright, is performed in a vacuum. The gold, silver, or other material is broken into molecules by evaporation, the molecules then being "bombarded" onto the base. Molecules are deposited in rectilinear propagation so tenaciously that even chemical reactions do not dislodge them. Quartz molecules may be deposited over the other coating to protect the surface indefinitely. The process will be used principally for resilvering reflectors.

WASHING MACHINES at lower prices have recently been announced. One is the "Faultless" washer, built to sell for $49.50. It has a full porcelain enameled tub, an enclosed gearbox with steel cut worm and worm gear running in oil. The agitator is cast aluminum. A lacquered steel apron covers moving parts. A type in the next higher price range, $79.50, is the "Automatic Champion," with a porcelain tub carrying a stationary bottom type agitator. The motor is mounted on a rubber insulation base attached to a drawn-steel apron. The worm and worm-gear unit, clutch unit, and eccentric and pitman are of the same design as those incorporated in a higher priced machine by the same company, but a segment gear and pinion have been substituted for the costlier machine's cable drive. Segment gear parts are of laminated steel to provide quieter operation operation. The transmission unit is fully inclosed in a cast iron and pressed steel case with all gears running in oil. The "Speed Queen," in the next price class, $99.50, has a heavy gage, seamless, drawn Monel metal tub, high-speed clutch, 2½ in. "balloon" wringer rolls, nickel-plated wringer, black Bassic Atalsite spring casters, polished removable splash ring, automatic wringer lock, and drawn-steel full-length legs. The new flat-table-topped "Dexter," meanwhile, selling at around $175, has twin vitreous-enameled rectangular tubs housed in a special drawn steel cabinet. The "turbolators" are cast aluminum, held in place by nickeled steel caps and the agitator is cupped over a bead in the tub bottom to prevent clothes working under it. The wringer is centrally mounted.



FOUR-SPEED operation, steering the only manual task, and an engine mounted behind the operator are design points in the "Caterpillar Auto Patrol" highway maintenance unit, which utilizes a power takeoff from the engine to perform adjusting movements



INDIVIDUAL drive for each wheel, made possible by split axles and a cradle motor mounting, is incorporated in the Lehigh Valley Transit street railway car

ONE interesting design improvement in textile machinery is a high-speed rotary-traverse winder having no reciprocating part for traversing the yarn lengthwise of the "package," (cone or tube on which the yarn is being wound). There is no perceptible friction or strain imposed on the yarn and it is therefore possible to run the machine at exceptionally high speed. A feature of the travel rolls lies in the construction of the grooves at the point where they cross. In order to insure that the yarn will be guided from one end of the package to the other and back again, and to insure positively controlled feed even at high speed, the grooves are formed so that the bottom of one is at a different level from that of the other at the crossing point. Also, the projecting point at the crossing of the grooves is chamfered. In order to insure uniformity, the grooved drums are molded of Bakelite. For high speed and free and easy running, the traverse rolls or drums are mounted on a shaft running in ball bearings. The only other revolving shaft is the stopping camshaft, which is slow turning, driven through a reduction gear.

It requires a 1½-hp. motor to drive one side of 50 spindles, or two motors for a full row of 100 spindles. It is claimed that 800 to 1,000 yd. per min. may be wound. An endless fabric belt conveyor, chain driven off of the stopping camshaft runs underneath through the center of the machine to carry away the empty bobbins from both sides of the machine.

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EXHIBITS at the Fifth Midwest Power Show held at Chicago clearly pointed out the present trend in the design of power plant equipment as a result of the use of higher steam pressures and temperatures. According to *Power*, the exhibit included an indicating gage for pressures up to 5,000 lb. per sq.in., having a Bourdon tube bored out of a special steel alloy designed to give uniform expansion and contraction throughout the entire range of the gage; an alloy steel helical movement for recording gages, of one-piece tubing, all-steel and all-welded; flow meter bodies for pressures up to 5,000 lb. per sq.in., made of heavy, seamless, open-hearth tubing with flanges and top caps made from solid blocks of steel. New designs of lubricated quarter-turn cocks and gate valves for pressures up to 1,500 lb. per sq.in. were shown. Two companies exhibited systems using Selsyn motor-operated remote control valves.

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PORTABLE electric radiators introduced by the Industrial Manufacturing Company weigh but 19 lb., yet have a radiating surface of more than 1,800 sq.in. Sections are of sheet steel, finished in baked black japan. Edges are trimmed in nickeled brass, the carrying handle is of aluminum, and legs are of malleable iron.

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AN UNUSUAL expansion joint for high-pressure service has its elastic elements made up of 3½ per cent nickel-steel annular disks welded at the edges. After being assembled by welding, the element is heat-treated to secure an elastic limit of 175,000 lb. per sq.in. The disks are of S.A.E. 2335 nickel steel.

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THE Wicaco internal precision grinder has the wheelhead motor mounted below the carriage to minimize vibration.

AIRCRAFT manufacturers are looking forward hopefully to the Detroit Air Show where many new models will be exhibited, including several light planes intended for quantity production. One such single-seater plane, the "Flying Bull Pup," built by the Buhl Aircraft Co., has a three-piece all-duralumin monocoque fuselage with integral fin, presumably stamped out. With a 45-hp. Szekey engine, this plane is said to consume only three gallons of gasoline an hour while traveling at its cruising speed of 76 m.p.h., or less than most light automobiles. A trend involving more amphibian planes also is anticipated. One of these is a new cargo plane, the first for commercial use to be offered by the Douglas Aircraft Company. It is powered by two 300-hp. Wright engines mounted above the main wing in nacelles, on top of which is a small removable auxiliary wing having 48 sq.ft. of area, intended to smooth out air flow and to reduce landing speed. The hull is constructed entirely of flat Duralumin sheet and open channel sections. This ship weighs 5,605 lb. empty and carries 2,395 lb. of useful load. It has a 60-ft. wing span. Planes more attractive in appearance as well as capable of higher speed will be seen at the show, as these are recognized as factors of importance in effecting sales. To permit of higher speed, engine power has been increased in many cases without weight increase.

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Expenditures For Industrial Research

RESEARCH expenditure per plant for all industries in the United States averages $44,500, according to the National Research Council. Expenditures for research per plant per year for some of the more important industries are as follows:

Industrial Groups	Average Annual Research Expenditure
Chemical and allied products	$105,000
Automobiles	100,000
Rubber and its products	100,000
Metal-working plants	68,300
Food and kindred products	47,000
Paper and pulp	38,400
Textiles	20,000
Rolling mills and steel plants	16,200
Leather and its products	15,200
Lumber and its products	13,600

Average expense for research per cent of capital invested for all industries for which data was available was 1.03 per cent. The range of variation was 0.04 to 2.04 per cent.

Standards and Specifications

FORMULATION of standards for electric welding apparatus, including definition of terms, classification, rating, heating, efficiency, dielectric test methods, standard variations in current and voltage, and nameplate data, is the proposed scope of the new project under the sponsorship of the A.I.E.E. and the National Electrical Manufacturing Association.

Personnel of the Sectional Committee on transmission chains, sprockets, and cutters has been reported by the A.S.A. The scope of the project is the formulation of American Standards for transmission roller chains and sprocket teeth, based on the standards already adopted by the A.S.E., A.S.M.E., and the American Gear Manufacturers' Association, and a study of the possibility of standardizing the so-called silent-transmission chain sprockets.

Proposed American Standards for hose couplings and screw threads for all connections having nominal inside diameters of $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, and 2 in., has been released for general criticism and comment. The proposal includes the form and pitch of the thread in addition to dimensional tables for hose couplings for steam, water and air services (fine threads); and hose couplings for certain other applications. The basic form of thread is the American National Standard, having an included angle of 60 deg. and truncated at top and bottom.

Proposed American Standards for rotating air cylinders and adapters (A.S.A. B5g1) one of the series of standards for small tools and machine tool elements completed recently by a Technical Committee of the A.S.M.E. Sectional Committee on Small Tools and Machine Tool Elements, is being distributed to industries for criticism and comment.

The following proposed Federal Specifications have been partially revised and are being submitted to representative manufacturers for comment and criticism.

Specification No. 571 on bolts, nuts, studs, tap rivets, and materials therefor.

Specification No. FF-N-101 on nails, spikes, staples, and tacks.

Specification No. TT-R-791 for rust-preventive compound.

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"Clearing House" For Design Data

TEACHERS of Machine Design in colleges and technical schools have formed a "Clearing House," the purpose of which is to exchange problems in machine design, research data, ideas as to methods of teaching machine design, and other information of mutual interest. Material contributed by the members is sent to the chairman, Prof. Frank L. Eidmann of Columbia University, and mimeographed copies are distributed to the members.

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Meetings

Three-M-Congress — Management, Maintenance, and Materials Handling Congress and Second National Industrial Equipment Exposition, Cleveland, Ohio, April 13-18, 1931. In the Arena and Exhibit Hall, Cleveland Public Auditorium. Information from the A.S.M.E., 29 West 39th St., N. Y. C.

American Society of Mechanical Engineers—Calvin W. Rice, executive secretary, 29 West 39th St., New York. The following meetings are scheduled: Semi-Annual meeting, Birmingham, Ala., Apr. 20-23, 1931. National Aeronautic Meeting, Baltimore, Md., May 12-14, 1931. National Applied Mechanics Meeting, Purdue University, Lafayette, Ind., June 15-16.

American Foundrymen's Association—Annual convention and exhibition, Stevens Hotel, Chicago, May 4-8, 1931. C. E. Hoyt, 222 West Adams St., Chicago, secretary.

THE BUHL "Flying Bull Pup" single-seater light plane

News of the Metal Markets

COPPER, selling at around 10c. on March 19, is going principally to fabricators buying copper at current levels against shipments of finished products to consumers. Export business is comparatively dull. February production, day by day, was higher than that of January, and increased Soviet copper production is probable—these combine to make the possibility of sudden price change remote, although there is general feeling that the trend is upward. Brass interests are increasing their takings slightly, and there is a greater quantity of wire business expected this Spring, according to *Metal & Mineral Markets*.

LEAD statistics seem to indicate little change in price, for stocks are still increasing, sales are small, and the London market is weak. Prices were around 4.5c., New York, on March 19, with price concessions being made to consumers in unfavorable geographical locations. With the seeming apathy of producers toward curtailment of production and the lack of sales to babbitt makers, corroders, and battery builders, there seems little to indicate a price change soon. February's sales, were, however, highest since those of last November. Increasing attention is being given to use of lead as a vibration dampener for buildings.

ZINC sellers feel that the situation is slowly improving, hence hesitate to push sales at the 4c. level. Production has been curtailed, indicating price increases as soon as the promised European curtailment occurs. March stocks were up, however.

TIN demand is dull and prices are comparatively stable at around 27c., in spite of the agreement to limit production. February visible stocks increased, though this is interpreted as an effort by producers to produce as much tin as possible before the curtailment agreement went into effect. Purchases are principally for immediate use.

INDIUM, one of the rarest of metals, white, lustrous, soft, ductile, and meltable in the heat of a match, has long baffled those who tried to extract it from its ores. During the past month, however, the Grasselli Chemical Company has succeeded in extracting a pound of it, at a cost of about $7,000.

IN THE SPOTLIGHT—

WILLIAM L. BATT, president of SKF Industries, Inc., has been appointed a director of the recently created Research Foundation at Purdue University.

A. H. ARMSTRONG, consulting engineer of Schenectady, N. Y., spoke on "Railroad Electrification" on March 20 before the Lehigh Valley Local Section, A.S.M.E.

DR. A. E. BECKER, in charge of the fuel and lubrication section of the Standard Oil Development Company, Elizabeth, N. J., has been placed in charge of the knock-testing laboratory of the company at Westfield, N. J.

EUGENE BRANDEIS has been elected president of the Lundie Engineering Corporation, New York, to succeed the late Dr. John Lundie. L. B. ARMSTRONG has been elected vice-president.

HOY CLARK, engineer in the Cleveland offices of the Cleveland (Ohio) Wire Spring Company, has been transferred to the Detroit staff in an engineering and sales capacity.

FRED CLIFFE, chief engineer with the Laycock Engineering Company, Ltd., Sheffield, England, has resigned to become designer with Tecalemit, Ltd., of London.

AUGUSTUS WOOD, formerly chief engineer and works manager of the Niles Tool Works, Hamilton, Ohio, has returned to the company as consulting engineer. He resigned as chief engineer and works manager in 1920.

GEORGE A. CROSBY, design engineer with Brooks Steam Motors, Inc., Buffalo, has become a design engineer for the Super-Steam Products Company, Inc., Trenton, N. J.

GEORGE F. CROUCH has joined the firm of Young & Crouch, New York City, engaged in the engineering, designing, and selling of marine engines and boats. In 1925, Mr. Crouch became vice-president of the Horace E. Dodge Boat Works, Detroit, and in 1930 president of George F. Crouch, Inc., Middletown, Conn.

CLARK P. POND has been appointed vice-president of engineering and sales of the Truscon Steel Company. He was formerly connected with the David Lupton's Sons Company in a similar capacity.

A. C. DANEKIND of the General Electric Company, spoke on "The Relation of New Machine Tool Design to the use of Tungsten Carbide and Anti-Friction Bearings" at the March 5 joint meeting of the Bridgeport Local Section A.S.M.E., the Engineers' Club, and local sections of the A.S.S.T., and other technical societies.

VENUSWAMI IYENGAR, assistant superintendent of the motor section of the Government Industrial Institute at Madura, India, has resigned to become engineer in charge of the workshop of R. Patel & Company, Madras, India.

CHARLES DRUM, formerly chief inspector of the Murray Corporation of America, has been made general superintendent to succeed William Klan.

HAROLD F. GATES, formerly plant engineer of the Hudson Motor Car Company, has joined Mechanical Handling Systems, Detroit, as chief engineer.

M. O. GRIFFITH, formerly chief engineer of power plants with the Crosley Aircraft Company, Cincinnati, has become a test engineer with the Stanwood Corporation, Covington, Ky.

William L. Batt

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Augustus Wood

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Clark P. Pond

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DR. WILLIAM J. FOSTER, 70, Schenectady, N. Y., has received the Lamme Medal of the A.I.E.E., "for his contributions to the design of rotating alternating current machinery." The medal will be presented at the Summer Convention of the Institute in Asheville, N. C., June 22-26. Dr. Foster is a retired consulting engineer of the General Electric Company.

JOHN P. GATY, formerly research engineer with the Bound Brook (N. J.) Oil-Less Bearing Company, has taken a similar position with the Hantra Company, New York City.

MATTHEW P. GRAHAM, who became affiliated with Thompson Products, Inc., Cleveland, in 1922, as chief engineer, and who has since been appointed factory manager, has recently been appointed general manager of the Detroit plant of the Thompson Products Corporation, a subsidiary.

FRANK M. HAWLEY has been appointed chief engineer and sales manager of the Automotive & Marine Divisions of the Morse Chain Company, Detroit and Ithaca, N. Y.

ALBERT S. HEINRICH, until recently chief engineer with the Aeromarine Klemm Corporation, Keyport, N. J., has joined the Bendix Research Corporation, East Orange, N. J.

C. F. HIRSHFELD, chief of research of the Detroit Edison Company, spoke on "Research in Industry" at the Feb. 24 meeting of the Philadelphia Local Section, A.S.M.E.

FRANCIS HODGKINSON, consulting engineer of the Westinghouse Electric Manufacturing Company, East Pittsburgh, Pa., has been awarded the Williams premium, an outstanding British engineering honor. Mr. Hodgkinson is an authority on steam turbines and marine machinery and was selected for the award by the Institution of Mechanical Engineers of London for submitting the best paper published in the proceedings of the Institute for the period 1925-1930 inclusive. Mr. Hodgkinson's paper was on "Journal Bearing Practice."

CLARENCE A. HUBERT, previously automotive engineer for the Hall-Scott Motor Car Company, Berkeley, Calif., has joined the DeVaux-Hall Motors Corporation, Grand Rapids, Mich., as engineer.

R. HUFFORD has been elected vice-president in charge of engineering of the Monarch Governor Company, Detroit. He was previously general manager.

DR. RALPH B. KENNARD, formerly head of the physics department of Robert College, Istambul, has been appointed a research associate of the Bureau of Standards, Washington, D. C.

LEWIS D. LINDEMUTH, consulting engineer, has been appointed vice-president and general manager of the Marine Steel Corporation, New York City, to develop the use of corrosion-resistant alloy steels in marine applications.

FRANK J. JESCHKE has joined the Hutto Engineering Company, Detroit. Mr. Jeschke was one of the originators of production cylinder honing and was with Hutto from the beginning of the company in 1923 to 1927, when he formed his own company, the Jeschke Tool Corporation, later merged with the Micromatic Hone Company.

DR. C. H. LORIG, specialist in foundry research, assisted by CLYDE E. WILLIAMS, will have charge of the research work in connection with a project planned by the Ohio Steel Foundry Company and the Battelle Memorial Institute. The project includes a comprehensive study of steel foundry practices with a view to developing of improvements and economies in the industry.

LOUIS A. LYZENGA, formerly a tool designer with the Hudson Motor Car Company, Detroit, is now at work as a private experimental and production engineer in that city.

FREDERICK W. MIERKE, for the past two years turbine engineer with the General Electric Company, Schenectady, N. Y., has joined the engineering department of the Beloit (Wis.) Iron Works.

RALPH MODJESKI, well-known Chicago consulting engineer and holder of the John Fritz medal, Franklin medal, French Legion of Honor, and several honorary degrees as Doctor of Engineering, received the Washington award for 1931 "for his contribution to transportation through superior skill and courage in bridge design and construction." The award is made by the Washington Award Commission, which consists of members of the Western Society of Engineers and the four founder engineering societies, the A.S.C.E., A.S.M.E., A.I.M.E., and A.I.E.E.

F. D. NEWBURY, general manager of machinery engineering of the Westinghouse Electric & Manufacturing Company, will deliver a paper on "Improving Drafting Management" at the National Management Meeting of the A.S.M.E. in Cleveland, April 13-14.

D. C. PRINCE has been appointed engineer of the Switchgear Department of the General Electric Company, Philadelphia, including supervision of switchgear research activities at Schenectady.

W. S. PRITCHARD, previously experimental engineer with the Motor Products Corporation, Detroit, has become factory manager with the Detroit Aircraft Corporation.

JAMES W. OWENS, director of engineering of the Welding Engineering & Research Corporation, New York City, spoke on "Residual Stresses" at the March 16 meeting of the Philadelphia Local Section, American Welding Society.

HARRY E. ZUCK, formerly assistant investigator in the department of engineering research at the University of Michigan, Ann Arbor, has become an experimental engineer with the Lycoming Manufacturing Company, Williamsport, Pa.

MILLARD ROMAINE, manager of the Engineering Service Department of the Cincinnati (Ohio) Milling Machine Company, spoke on "Recent Milling Machine Applications" before the Machine Shop Practice Division of the A.S.M.E. at the Detroit Engineering Society, Feb. 16. Following this, HANS ERNST, research engineer of the same company, delivered a talk on "Hydraulic Applications in Machine Tools."

S. EDWARD ROWE, formerly assistant chief engineer of the Marmon Motor Company, Indianapolis, has become engine and chassis engineer with the Stutz Motor Car Company of America.

FRANK A. SCHOTTERS, formerly vice-president of the Plymouth (Ind.) Body Works, has been appointed director of engineering and sales manager for the Luce Manufacturing Company, Lansing.

FLOYD B. SELENSKY has been promoted from the engineering department of the John Deere Tractor Company, Waterloo, Iowa, to chief draftsman in the company's new-design department.

M. J. STEEL, in charge of Diesel design at the Packard Motor Car Company, spoke on "The Packard Diesel Aircraft Engine" at the March 12 meeting of the Schenectady Local section, A.S.M.E.

DR. BRADLEY STOUGHTON, professor of metallurgy at Lehigh University, has been appointed consulting metallurgist of the Standard Steel Works Company, Burnham, Pa.

F. D. Newbury

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James W. Owens

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DR. ANCEL ST. JOHN of the St. John X-Ray Corporation spoke on "Non-Destructive Tests of Welds" at the joint meeting, New York Section, American Welding Society, and the New York Chapter of the A.S.S.T. on March 9. DR. A. V. DEFOREST of the Welding Engineering & Research Corporation, spoke on "Magnetic Inspection of Steel Products," and DR. R. F. MEHL of the Naval Research Laboratory spoke on "Gamma-Ray Inspection of Heavy Welded Structures."

O. L. STARR, vice-president in charge of manufacturing of the Caterpillar Tractor Company, has been appointed vice-president in charge of the Research Division and will maintain headquarters at San Leandro, Calif. WALTER GROTHE will be his assistant. H. S. EBERHARD will be chief engineer of the division, and J. W. BRIDWELL his assistant. L. T. THOEN is now chief engineer of the Harvester Research Division.

SAMUEL M. VAUCLAIN, chairman of the board, Baldwin Locomotive Company, spoke on "The Modern Locomotive in the Development of the Water Tube Boiler" at the March 12 meeting of the Baltimore Local Section, A.S.M.E.

A. E. WECKERLY, construction engineer of the National Tube Company, Pittsburgh, has been appointed chief engineer at the Lorain (Ohio) plant to succeed George T. Snyder, who was transferred to Pittsburgh in January.

A. R. WEIGEL, formerly president of the Barnard & Leas Manufacturing Company, Moline, Ill., has resigned to engage in consulting engineering work.

WALTER F. WHITEMAN, riding-quality engineer with the Motor Rim Manufacturers Company, Cleveland, has joined the design and research division of the Gabriel Company, Cleveland.

A. B. WRAY, formerly sales manager of the Industrial Division, Morse Chain Company, Ithaca, N. Y., has been named chief engineer of the same division.

E. E. YAKE has been made a vice-president of the Worthington Pump & Machinery Corporation, Harrison, N. J., to direct engineering and manufacturing.

Obituaries

ALEXANDER LUCHARS, 77, mechanical engineer and founder 50 years ago of the Industrial Press, publisher of "Machinery," technical books, and technical magazines, died in Montclair, N. J., Feb. 19 of pneumonia.

WILLIAM D. CONDIT, 83, developer of the Savage automatic pistol and several rapid fire guns, died of paralysis in Alhambra, Calif., March 13.

LOTHAR R. ZIFFERER, 41, inventor of a type of expansion bolt, died in Columbia, Pa., of pneumonia, Feb. 19. Mr. Zifferer was the organizer of the Standard Expansion Bolt Company.

NEW MATERIALS AND PARTS

AND

ENGINEERING EQUIPMENT

Reeves Inclosed Transmission

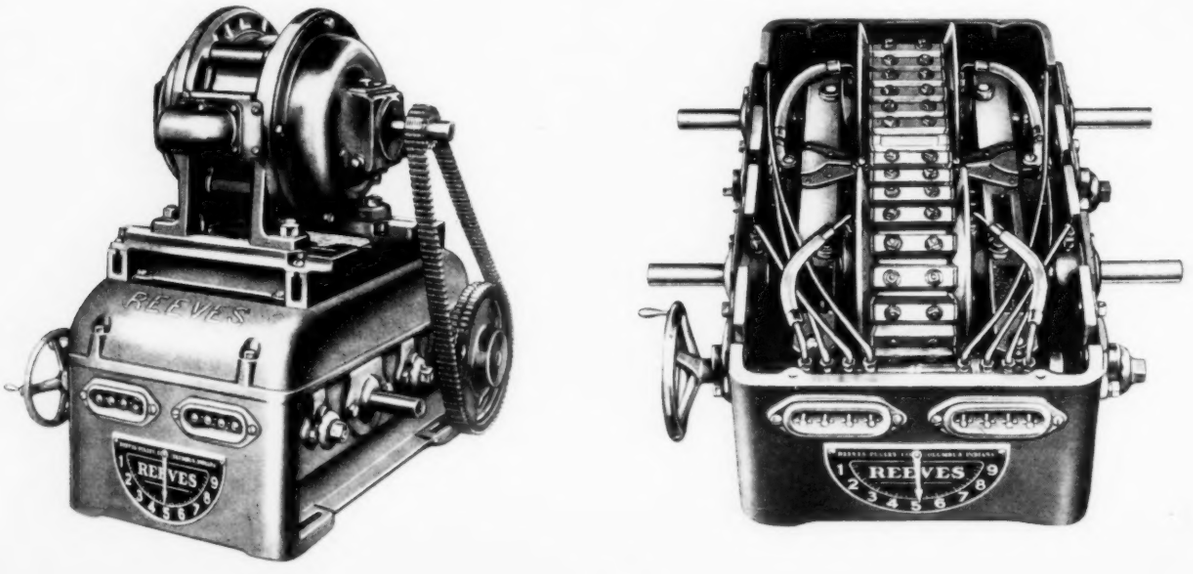
STANDARD internal operating parts of the Reeves transmission are totally inclosed in a compact, attractive, and symmetrical cast iron housing, as announced by the Reeves Pulley Company, Columbus, Ind. This inclosure affords complete protection in all machine applications where the operating parts of the transmission must be guarded from water, live steam, chemical fumes, or abrasives. Easy access to the interior is provided by U-shaped recesses in the sides of the bottom section, and permit the removal, as a unit, of the operating parts, including the bearings of the two shafts, as well as the shifting and belt-tightening screws. Removal of the lid from the cover section permits minor adjustments, inspection of the internal operating parts, or installation of a new V-belt.

An outstanding feature of the Reeves inclosed transmission is the improvement in lubrication facilities. Complete lubrication of all bearings is accomplished through force feed fittings located in two recessed panels at one end of the transmission. From these eight fittings rigid copper tubes lead to the four radial shaft bearings, and flexible copper tubes lead to the four thrust bearings fitting around the disk hubs. By means of openings from the thrust bearings, the lubricant is also forced into the spiral grooves of the disk hub bores, thus lubricating the disk hubs, shafts, and driving keys. Each transmission is shipped with all bearings and connecting tubes packed with lubricant. Lubrication is necessary only once in every 30 to 45 days, depending upon the type of service.

The inclosed Reeves transmission is built in six sizes, covering from fractional to 10 hp. requirements, in all speed ranges. It can be mounted on the floor, ceiling or in the vertical position. The cover section accommodates adjustable motor rails and cross-rails, on which a complete motor unit or auxiliary countershaft unit may be mounted for varying requirements of machine-speed control. These rails are bolted to each side of the transmission cover, outside the space occupied by the lid of the cover section, leaving the lid entirely accessible for removal. The cross-rails, on which the motor is mounted, are also slotted for adjustment, and will permit any design or type of motor of the proper horsepower to be mounted.

"Plasket" Packing Material

THREE grades of a plastic, nondrying packing material, known as "Plasket" are being marketed by the A. & E. Company, 540 N. Michigan Ave., Chicago, Ill. Plasket No. 1 is for packing pipe joints, flanged or threaded, for saturated and superheated steam, hot and cold water, air, gas, brine, and liquid ammonia.

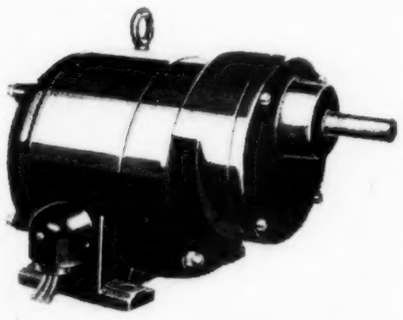


Left—Inclosed Reeves Variable-Speed Transmission, equipped with motor base and driving motor. Right—Top cover of unit removed to show the force-feed lubrication system

Grade No. 2 is for sealing joints where gasoline, oil, tar, paraffine, and ammonia gas are present, while grade No. 3 is for general purpose use. It is said that the material will function under vibration and will withstand expansion or contraction of the adjacent parts. It is unaffected by any of the substances with which it comes in contact. Because the material remains plastic indefinitely, the joint can be demounted at any time. Plasket comes in cans of from 5 to 25 lb. It is applied with a spatula or putty knife.

Master Geared-Head Motors

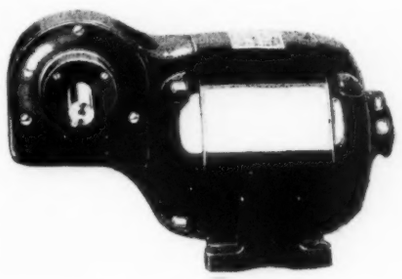
Motors incorporating speed reducers are available in parallel-shaft and right-angle-shaft designs from The Master Electric Company, Dayton, Ohio. The parallel-shaft type is built in sizes from 1/30 to 5 hp., in single-phase and d.c. models, and from 1/30 to 20 hp., in polyphase models, with interchangeable frames for the same horsepower and speed in different types. The parallel-shaft type is available in multiples of 0.25 for any ratio between a maximum reduction



Master Geared-Head Motor of parallel-shaft design, available in sizes from 1/30 to 20 hp., and employing continuous-tooth herringbone gears

of 6 to 1 and a maximum acceleration of 2.5 to 1 of standard motor speed. It is equipped with anti-friction bearings throughout. Gears are of the continuous-tooth herringbone type. Both gears are of steel. Where quietness is essential, a composition gear can be supplied. The gear housing can be arranged so that the shaft projects in any one of four different positions—either at the top or bottom on the vertical center-line, or to the right or left on the horizontal center-line. An oil-seal arrangement is provided, necessitating lubrication only at 1,000-hour intervals of service.

The right-angle-shaft type motor is built in sizes from 1/30 to 5 hp., single-phase and d.c., and 1/30 to 10 hp., polyphase, with interchangeable frames for the same horsepower and speed in the different types. Standard ratios range from 8 to 1 to 72 to 1 in nine steps. This type is also equipped with anti-friction bearings throughout, but employs a worm-



Master Geared-Head Motor of right-angle shaft design, available in sizes from 1/30 to 10 hp., and utilizing a worm gear reduction

gear reduction. The worm-gear housing can be arranged so that the shaft projects in any one of eight different positions—on either side of the housing with the housing at the top or bottom on the vertical-center line, or to the right or left on the horizontal center-line. This type also has an oil-seal arrangement to minimize the necessity for lubrication.

Globe Stainless Tubing

THE Globe Steel Tubes Company, Milwaukee, Wis., has organized a subsidiary to be known as the Globe Stainless Tube Company, to carry on the business of engineering, designing, and manufacturing stainless steel tubes and tubular installations for corrosion and heat-resisting purposes. Sales will be handled through the sales offices already established in principal cities by the Globe Steel Tubes Company.

The stainless tubes are available in a range of compositions. The 12-15 per cent chromium alloy is furnished in tubes from $\frac{3}{4}$ to $1\frac{3}{4}$ in. outside diameter. In the 15-18 per cent alloy, standard pipe sizes available range from $\frac{3}{8}$ to 5 in., together with miscellaneous tube sizes. In the 18 chromium, 9 nickel, and 0.07 carbon alloy, pipe sizes range from $\frac{1}{8}$ to 5 in., together with miscellaneous tube sizes. In the 18 chromium, 9 nickel and 0.12 carbon alloy, tubes up to 4 in. are available, while in the 20 per cent. chromium alloy, tubes are available from 1.900 in. to $5\frac{3}{16}$ in., outside diameter. A 4 to 6 per cent chromium alloy is available only in the 1-in. pipe size.

Monitor Lotrip Switch

REVERSE-TORQUE or plug-reverse braking of a.c. motors is the function of the "Lotrip" switch announced by the Monitor Controller Company, Baltimore, Md. In operation, this switch automatically disconnects the motor from the line just before it comes to rest. Therefore, the Lotrip switch is particularly suitable for applications where motor reversal must be prevented.

The Lotrip switch consists of a contact switch in the coil circuit of the brake line contactor. This contact switch is held closed by pressure from an arm mounted on a friction ring and carried by a rotating shaft driven by the motor to be controlled. Normally, the friction ring slips and the arm exerts no pressure on the contact arm, but when the speed of rotation decreases to a definite low value, a quick-action centrifugal regulator throws a clutch that applies friction to the ring, and thus exerts the pressure necessary to close the brake contactor circuit. This contact remains closed until the brake circuit comes into action and the motor slows down to the critical trip-speed, when the centrifugal regulator snaps back to its normal position and the brake circuit is opened, disconnecting the motor from the line.

The whole mechanism is enclosed in a cast-iron case provided with mounting feet and a drive pulley. The same switch can be used for braking in either direction, or in both directions by changing the arms.

NEW MATERIALS AND PARTS

Brown & Sharpe No. 55 Rotary Geared Pump

BALL bearings and spiral gears are employed in the No. 55 rotary geared pump announced by the Brown & Sharpe Manufacturing Company, Providence, R. I. This pump replaces the No. 5 previously manufactured. Improvements in the design and construction of this pump make it particularly applicable for supplying oil under pressure for hydraulic operation of machines. The cap, stand, and housing are reinforced. Two more bolts have been added. This increases the clamping effect by 30 per cent and permits the use of high pressures without danger of blowing the gaskets. The suction port, including the

pipe tap, has been made larger to permit free entrance of oil. Changes in the discharge port tend to minimize the load on the bearings, and thus cause them to wear longer.

The No. 55 pump at 1,200 r.p.m. delivers approximately 36 gal. per min. at 100-lb. pressure. The pump is also suitable for Diesel-engine lubrication.

"Speedage" Fabric Belt

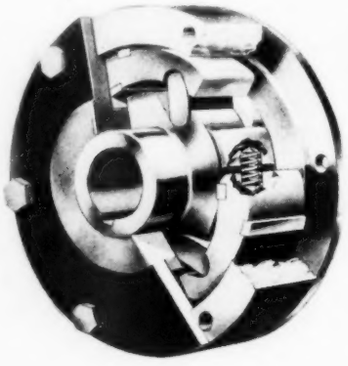
ENDLESS woven fabric belts have been placed on the market by the L. H. Gilmer Company, Tacony, Philadelphia, Pa., under the trade name of "Speedage." They are especially designed for high-speed, small pulley work and are furnished in light, medium, and heavy weights in different numbers of ply. They can be used on pumps, compressors, grinders, drill presses, routers, carvers, and polishing or buffing machinery. There is no high point in the belt to produce vibration when operating at high speed. Slip can be further reduced by applying "Gilmerite."

"Speedage" belts in the light and medium styles are made in widths from $\frac{3}{16}$ to 10 in., and in the heavy style in widths from $\frac{1}{2}$ to 10 in.

"Pitter" Improved One-Way Clutch

IMPROVEMENTS tending to simplify the construction and make it more wear-proof have been made in the "Pitter" one-way clutch manufactured by the Universal Gear Corporation, 327 S. LaSalle St., Chicago. The device was previously described in the August, 1930, number of *Product Engineering*. Like the original design, the clutch locks and releases instantly and will not slip. The greater the load, the tighter the lock becomes.

The clutch consists of a central forged steel hub, on either side of which are two hardened and ground steel races; a hardened and ground outer steel race; and three shoes, with toggle members to lock them between the inner and outer races. In the redesigned clutch contact between the shoes and races takes place through alloy-steel inserts, case hardened and ground. The bearing contact presents a large surface area against both the inner and the outer races, instead of



line contact, and reduces the unit load and adds to the wear life of the unit. Wedging of the shoes is by toggle arms or by struts, which have rounded ends to insure ample contact area in the shoes and in the steel hub. Pins formerly used to hold these members in place have been eliminated from the design, and compression springs now replace the tension members. They keep the shoes in light contact with the races and take up wear. Thus, the clutch is guaranteed not to slip after extended use.

All parts operate in oil, and all movements take place when there is no load. When the driving load is applied, relative movement has ceased. The number of times that the clutch can be started and stopped with the shoes locking and unlocking is practically unlimited. Wear is negligible, and the parts have been designed to be stronger than the connecting shafts.

The Pitter clutch is intended to replace ratchets, "no-backs," and overrunning coupings. It is particularly designed for converting alternating motion, either reciprocating or rotary, into one-way movement. Drive may be through either the outer ring or the hub at the center. The clutches range in size from $\frac{1}{2}$- to 4-in. shaft sizes and range in torque from 204 to 124,800 in.-lb.

Master Explosion-Resisting Motor and Switch

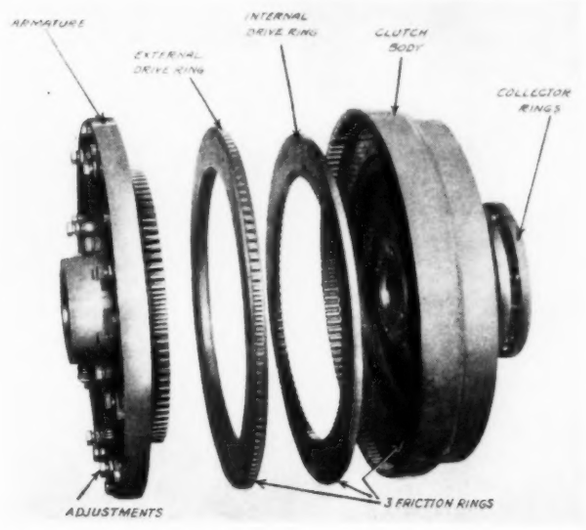
COMBINATION of an explosion-resisting motor and switch in one unit by The Master Electric Company, Dayton, Ohio, eliminates the hazard of extra wiring, piping, and splicing required by the usual installation of a separate switch, particularly where explosive vapors are present. The motor leads are brought out through the motor frame to permit the removal of both end covers without disturbing the seal. The motor is of moisture-proof construction and has quiet operation, high-starting torque, and large overload capacity. The unit is designed for either horizontal or vertical shaft operation and is suitable for use

NEW MATERIALS AND PARTS

wherever the surrounding atmosphere may be inflammable. It is available in sizes from $\frac{1}{8}$ to $\frac{1}{3}$ hp., in repulsion-induction, polyphase, and d.c. models, all of which are interchangeable as to external dimensions.

Stearns Multiple-Disk Magnetic Clutch

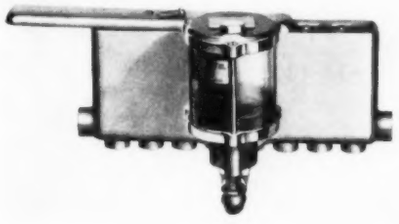
LARGE-SIZE multiple-disk magnetic clutches of compact design are being placed on the market by The Magnetic Manufacturing Company, Milwaukee, Wis. These "Stearns" clutches eliminate cumbersome bulk, high cost, difficulty of alignment, and other difficulties associated with large-size clutches. They provide maximum horsepower, large pull-out torque, smooth acceleration, and low maintenance cost.



A typical clutch is illustrated. This clutch is 24 in. in diameter and provides over 6,500 ft.-lb. pull-out torque. The large friction lining provides for low pressure and long life.

Daun-Walter Adjustable-Wick Oil-Feed Unit

AN ADJUSTABLE-wick oil-feed unit has been placed on the market by the Daun-Walter Company, 508 North Water St., Milwaukee, Wis. for supplying oil to various types of bearings. This unit is available with a reserve supply of $\frac{1}{2}$ pint to 2 gals. The equipment has no moving parts and provides a positive continuous control over the quantity of oil fed to



each bearing. It consists of two elements, the "D-W" constant-level oil control and the D-W adjustable-wick, oil-feed multiple unit or wick box. The wick box is of cast aluminum with a removable cover and is made to have 4, 8, or 12 outlets. The horizontal outlets on either side of the box enable the hooking up of other wick units when located on the same level. Provision is made for adjusting the height of the turn-down of each wick loop, which determines the quantity of oil fed by the wick. The level of the oil in the wick chamber is stationary. A minimum oil feed of four drops per hour can be maintained. Capillary attraction draws the oil up over the loop against gravity, so that the higher the loop the less oil is fed. This permits adjusting the feed.

Fansteel Tungsten Products

BARS, sheets, wire, powder, and salts of tungsten are now obtainable from the Fansteel Products Company, Inc., North Chicago, Ill. The company has been manufacturing tungsten since 1914, but it is now furnishing pure tungsten metal in all commercial forms for general purposes, whereas formerly it was sold only in the form of finished electrical contact points. In the reduction process, tungsten powder 99.5 per cent pure is obtained. The finished product is very workable and ductile. Tungsten has the highest melting point of the metals.

Howell Types EKCL and EKBB Inclosed Motors

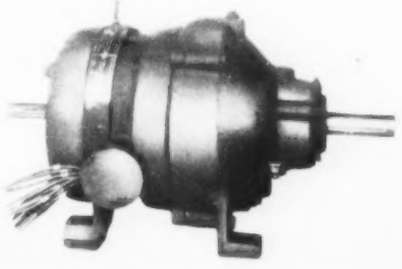
FOR Class 1, Group D, service, the Howell Electric Motors Company, Howell, Mich., has announced both polyphase and single phase motors with either totally inclosed frames or totally inclosed fan-cooled frames. The polyphase motors are of squirrel-cage construction with extra heavy castings. All machined parts

Howell Totally-Inclosed, Fan-Cooled Motor for Class 1, Group D Locations

have large fitting surfaces to correspond with the Underwriters' Laboratory requirements for this class of service. The single-phase motors are also of squirrel-cage construction, and are of the condenser-start type.

"Production" Motorized Speed Reducer With Two Shaft Extensions

ANY of the motorized speed reducers manufactured by the Production Equipment Company, Cleveland, Ohio, can be supplied with shafts extended at both ends. Either the same speed or different speeds can be had on the shaft extensions. The motor-



NEW MATERIALS AND PARTS

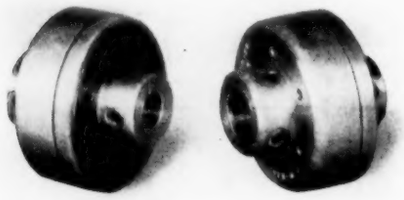
ized speed reducer consists of a standard or special polyphase induction motor, mounted integral with spur, helical, planetary, or bevel gears in an oil-tight casing. Shaft speeds may range from 20 to 875 r.p.m. With a speed reducer at one end only, the opposite shaft would have standard polyphase motor speeds, as specified.

Edmunnds Flexible Coupling

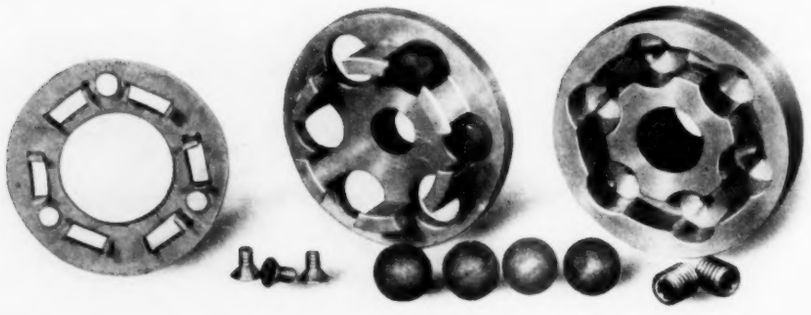
TORSIONAL resilience is provided in the Edmunnds flexible coupling, announced by the Crocker-Wheeler Electric Manufacturing Company, Ampere, N. J., by using rubber balls. The coupling also takes care of various forms of misalignment and shock. As shown in the illustration of the disassembled coupling, the flange half has six cylindrical pockets, all parallel to the shaft and a circular groove in the spaces between the pockets. The other half, the spider, has six projecting lugs between which are placed the rubber balls that absorb the shock. When the two half couplings are in place the balls occupy the pockets in the flange and, as the torque to be transmitted varies, the lugs on the spider half squeeze the balls correspondingly, and these provide the resilience needed for shock absorption. With this arrangement all the balls are under compression in either direction of rotation.

The balls may be removed for examination or renewal by first taking off the cover over the holes in the spider half, and then pushing out the balls by means of a rod, passed through the small holes in the flange half. This makes possible the removal of balls without disturbing the machine or either half coupling. Wear and tear can be localized in the balls, and thus increased life and reduced maintenance charges are obtained. An additional feature is that by removing the rubber balls, the motor or other driving mechanism can be disconnected from the load. This is often useful for testing purposes.

The Edmunnds flexible coupling is made in a range of shaft sizes from the No. 4 with a $\frac{1}{2}$-in. bore to the No. 31 with a $3\frac{7}{8}$-in. bore. The first will transmit $\frac{1}{8}$ hp. per 100 r.p.m., and the second, 35 hp. per 100 r.p.m. It is possible to have a larger bore in the flange half that has the cylindrical pockets.



Views of Edmunnds Flexible Coupling, showing the removable cover

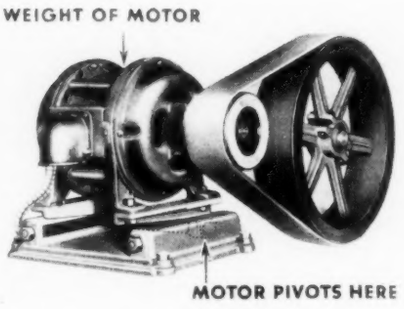


Disassembled view of Edmunnds Flexible Coupling, which employs rubber balls as the shock absorbing component

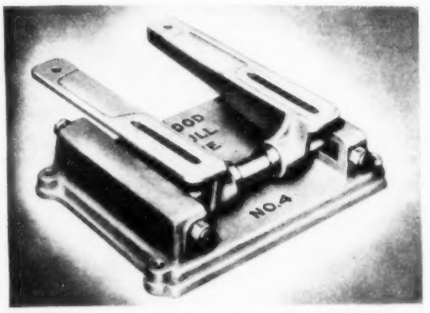
Rockwood Short-Center Flat Belt Drive

SHORT-CENTER flat belt drives in sizes from 1 to 50 hp. are carried in stock by the Rockwood Manufacturing Company, division of General Fibre Products, Inc., 1801-2001 English Ave., Indianapolis, Ind. This drive comprises a motor base, two pulleys, and a flat leather belt. Stock drives are designed for polyphase, 60-cycle, a.c. motors of any make.

This compact drive differs from other drives, in that the motor is mounted on a free-swinging pivot. The weight of the motor maintains uniform belt tension at all times and is unchanged by belt stretch or by centrifugal force. Thus, uniform belt tension assures constant pull and constant speed.



Illustrating how the weight of the motor maintains uniform belt tension in the Rockwood drive



Standard base for the Rockwood Short-Center, Flat Belt Drive, made in six standard sizes

The base may be mounted on a floor, wall, or ceiling to drive a single machine or a lineshaft. The only restriction for any application is that the driven shaft shall not be lower than the motor shaft. All-metal construction is used for the base and simple adjustments are required for motor size, pulley alignment, and belt length. The design eliminates the need for the usual motor rails. Six standard sizes cover requirements for motors from 1 to 50 hp.

"Hygrade" Leakproof, Vertical, Worm Gear Speed Reducer

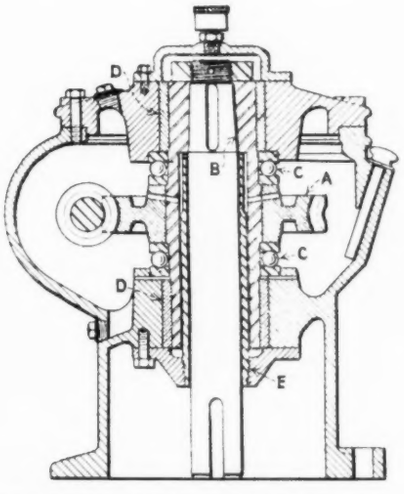
LEAKPROOF construction is a feature of the vertical worm gear speed reducers placed on the market by the Foote Bros. Gear & Machine Company, 111 North Canal St., Chicago, Ill. The leakproof feature is incorporated in any of the standard vertical "Hygrade" units at a small additional cost.

Referring to the cross-section, the bronze worm gear ring *A* is pressed

NEW MATERIALS AND PARTS

"Hygrade" Leakproof Vertical Speed Reducer, which is the standard model with leakproof feature added

on a splined hollow steel center *B* and is held rigid by two flat ball thrust bearings *C*. This assembly is mounted on the bronze bearings *D*, and the hollow center is securely fastened to the vertical shaft at the upper part of the reducer, thus forming a cavity below this point for nearly four-fifths of the entire length of the shaft. In this space is placed a tube *E*, which is sealed and fastened to the lower part of the reducer, from whence it extends upward to a point well above the oil level. At the top the opening of the tube is covered by the steel center *B*. This prevents oil from leaking out and forms two chambers, one in which the worm gear operates and the other in which the vertical shaft rotates free from oil. A large, heavy stuffing box is bolted securely to the drive shaft housing to prevent leakage of oil around this shaft.

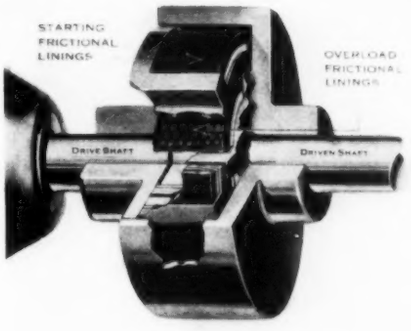


Cross-section of "Hygrade" Leakproof Vertical Speed Reducer, showing how oil is prevented from seeping out at the driven shaft extension by means of the inner sleeve

Rawson Automatic-Starting Flexible Coupling and Clutch

CENTRIFUGAL action is the fundamental principle of the Rawson automatic starter and flexible coupling announced by The Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass. The device consists of two cast iron members, one attached to the driving shaft and the other to the driven shaft. Between the driving and driven members are inserted floating segments made of brake lining reinforced with lead, a sufficient amount of lead being used to give the required pressure on the friction surfaces for carrying the load. Clearance is allowed between the driving and driven members and also between the floating friction surfaces.

With the application of power, centrifugal force begins to act on the outer set of linings. There is sufficient lag, however, to allow the driving member to come to full speed before centrifugal pressure takes effect on the driven member and, in



addition, the design is such that the centrifugal action on the driving side is never greater than the motor rating.

In starting a load with a clutch capacity for only the rated power of motor, some time would be required and considerable heat might be generated. In order to overcome this objection and to give sufficient overload capacity, a second set of centrifugal friction linings is introduced on the driven side, thus giving an auxiliary source of driving. This auxiliary power can be made in any amount desired, varying with the type of load and the overload requirements.

This starter is usually applied to motors, but may be applied to other types of driving units. It may also be applied to the driven unit. It can be arranged for direct connection, gear, chain, V-belt, or flat belt drives. No limit is set on the amount of power that can be transmitted with the design. It will operate in either a horizontal or vertical position, or in either direction of rotation.

Among the advantages of the Rawson starter are: Reduces peak load requirements for driving units; absorbs shocks and reduces wear and tear to both driving and driven units; standard motors and in many cases smaller motors may be used; minimum power is required and power factor is improved; wholly automatic operation, and inclosed design. The coupling is built in sizes to transmit from 3 to 300 hp.

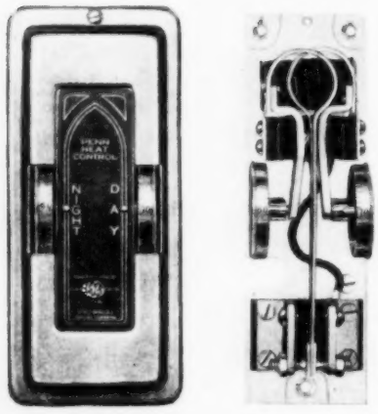
General Electric Oil Burner Equipment

A COMPLETE line of electric equipment for domestic oil burners has been announced by the General Electric Company, Schenectady, N. Y., making it possible for the burner builder to obtain a co-ordinated line of electric equipment of one manufacture. The equipment includes a complete line of motors, and control and ignition equipment.

The line of motors includes split-phase, reactor and capacitor type, single-phase, polyphase, and direct-current motors. The split-phase motors are available in standard ratings up to and including $\frac{1}{6}$ hp., and the reactor motors in standard ratings from $\frac{1}{4}$ to $\frac{3}{4}$ hp. These motors are applicable to burners which require relatively low or medium starting torques. The capacitor motors are

Penn Heat Oil-Burner Control Panel built by General Electric

NEW MATERIALS AND PARTS



General Electric Type CR2990-A1 Thermostat manufactured for Penn Heat Control Corporation. Left—front view. Right—cover removed

available in standard ratings from $\frac{1}{6}$ to $\frac{3}{4}$ hp., and are applicable to burners requiring exceptionally high starting torques. The polyphase and d.c. motors are available in all standard ratings, and with characteristics to permit interchangeability with any of the single-phase motors.

The control, while manufactured by General Electric Company, is marketed by the Penn. Heat Control Corporation, Philadelphia, Pa. The main panel embodies several features. Automatic re-cycling starting causes the burner to try to start four times in succession. At the end of each trial, the oil is shut off and any oil vapors are scavenged out of the combustion chamber before another trial is attempted. As soon as the burner is running, the flame detector bypasses the re-cycling mechanism and the operation becomes continuous. The second feature is electric timing by means of an electric clock with a 24-hour dial. The time settings on this dial are readily adjusted.

The control is also available without the automatic timing, thereby operating the burner to maintain a constant temperature throughout the day and night. The thermostat is small and compact. For the time control it consists of two blades, one controlling the house temperature during the day and the other operating during the night. Two models of high-temperature thermostats are available for shutting down the apparatus in case unburned oil is being projected into the combustion chamber. One model designed for mounting in the stack consists of a bi-metal helix operating a sensitive contact assembly. The other device consists of a sensitive contact operated by the expansion differential between a fused quartz element and a high-temperature alloy element. This device is mounted near the flame and gives fast operation.

"Victron" Molding Compound

HIGH electrical insulating and waterproof qualities are features of "Victron," a thermoplastic molding compound developed in the laboratories of the United States Rubber Company, Passaic, N. J., but marketed through a subsidiary, the Naugatuck Chemical Company, 1790 Broadway, New York, N. Y. The material falls within the class of the styrol plastics, being classed as a compound that is chemically inert. When molded it forms a colorless, transparent solid which may be colored to any shade desired or compounded with fillers. It is not brittle and may be machined without difficulty.

Dielectric strength of Victron is 517 volts per mil, obtained with a test piece $\frac{1}{8}$-in. thick. The power factor is 0.03 and the dielectric constant 2.96. When placed in a magnetic field of high frequency, the material does not burn. Suitable stiffness for insulating tubes, rods, or sheets is obtained by the addition of fillers. Non-absorption of water is another quality adapting the material to electrical uses. After submerging a specimen in water for 82 hours at 25 deg. C., the water absorption was found to be zero.

Molding temperatures and pressures for Victron are low, pointing to low cost for quantity production. The temperature required ranges from 120-140 deg. C., and the pressure from 300-500 lb. per sq.in. Other properties are: Specific gravity, 1.06; hardness on Moh scale, 2-3; softening point, 93 deg. C.; transverse strength, 7,000-8,000 lb. per sq.in.; tensile strength, 3,300-4,000 lb. per sq.in.; deflection under load (5,000 lb. per sq.in.), 0.118 in.; and coefficient of expansion, 0.000099 in., per in. per deg. C.

By means of a gas flame, sheets of Victron can be softened and shaped as desired. Autogenous joints in linings for acid tanks can be made, since the joints can be cemented with a solution of the compound and heated until the material flows together. Alcohol, moderately strong acids, and inorganic bases have no effect on the plastic. Its solvents are benzol, toluol, ethyl-dichloride, carbon tetrachloride, butyl acetate, and ethyl acetate, and the organic bases. In addition, the material can be placed in solution and sprayed. For this purpose, the lacquer is made in two grades, one as an undercoat and the other as a finishing coat.

PUBLICATIONS

FOR THE ENGINEER'S LIBRARY

ELECTRICAL EQUIPMENT. The Condit Electrical Manufacturing Corporation, Hyde Park Station, Boston, Mass., has issued Industrial Control Catalog No. 5016 on circuit breakers and motor starters of the air and oil types and also on service switches.

FIBRE. The Continental Diamond Fibre Co., Newark, Del., is distributing a comprehensive catalog on vulcanized fibre, discussing the manufacture, machining, applications, and giving specifications and useful tables.

LACQUER. The Hilo Varnish Corporation, Marcy & Flushing Aves., Brooklyn, N. Y., has issued bulletin No. 11 entitled "Hilo Lacquer," which is the third edition. Information is given on choosing lacquer, preparation of metal surfaces, processes of application, and systems to be employed.

MOTORS. The Wagner Electric Corporation, 6400 Plymouth Ave., St. Louis, Mo., is distributing bulletin 169, which discusses the mechanical and electrical characteristics of slip-ring motors, the four different types, and their speed-torque characteristics.

SPEED REDUCERS. The Horsburgh & Scott Co., Cleveland, Ohio, is distributing a circular describing small worm gear speed reducers and listing the horsepower ratings and dimensions.

SPEED REDUCERS. The D. O. James Manufacturing Co., 1114 W. Monroe St., Chicago, Ill., now has available catalog No. 135 on heavy-duty worm gear speed reducers, covering four new small sizes. Complete information is given as to dimensions and horsepower ratings at various speeds.

SPRINGS. The Hardware Products Co., 103 Richmond St., Boston, Mass., has prepared a list of "Preferred Sizes" of springs, the catalog representing a tabulation of data.

VALVES. The American Car & Foundry Co., 5718 Russell St., Detroit, Mich., has issued Catalog No. 1 on "a.c.f." Milliken valves, giving a complete exposition of this new type.

Plastic Molding Materials

Characteristics and Uses

TWO general classes of plastics are now used widely for mechanical parts: (1) Thermoplastics, or those that are worked under heat and can be reworked by reapplication of heat, as cellulose acetate, sold under trade names such as Lumarith, and (2) Thermo-setting, or those that take a permanent set under heat, or heat and pressure, and cannot again be melted, softened, or reworked. The most familiar of these is the phenol-formaldehyde resinoids sold under trade names such as Bakelite. The more usual of the plastics for mechanical use will be described here, but no attempt is made here to cover the cold-molding materials, or those made up with a pitch, or similar bond.

Celluloid, or cellulose nitrate with a hardener, is the oldest and best known of the so-called "plastics." Within the last few years, however, many other plastics and synthetic resins have been developed for mechanical and electrical parts. These have varied mechanical and electrical characteristics, and the designer today must be as familiar with them as he is with the metals

Phenolic resins. These are usually products made by the chemical reaction of phenol (carbolic acid) and formalin (formaldehyde solution). The product is a resinous substance, which when mixed with a filler of wood flour, mica, asbestos, or other material, is molded under heat and pressure in dies into such parts as electrical insulators, clock cases, handles, automobile steering wheels, and ornamental products. The color is a light amber, but by adding pigments or dyes any color except pure white and pastel shades can be obtained. The molding material is marketed in powder, "pills," and other forms, in which the chemical reaction has been only partly carried out. Once this reaction has been finally accomplished in the molds under a temperature of about 350 deg. F. and a pressure of 2,000 lb. per sq.in., the molded product is hard, insoluble, and very resistant. It can be machined only with difficulty with tungsten-carbide tools. The filler of wood flour is incorporated to make the product more economical, and also to toughen it and make it less brittle. The molded material has high electrical resistance, and for that reason has been much used for switch parts, and telephone and radio parts. The physical characteristics of the molded material depends largely upon the type and quantity of filler employed, and also somewhat upon the method of manufacture. A typical molded material with wood filler has a tensile strength of 10,000 lb. per sq.in., compressive strength of 30,000 lb. per sq.in., and specific gravity of 1.35.

The wood flour used as a filler and reinforcing material is usually of pine or spruce finely ground. The rosin in yellow pine is claimed to improve the physical characteristics, but woods containing essential oils, such as cedar, are not considered suitable. To give greater flexibility to the molded materials so that they can be sheared or punched, a vegetable oil, glycerol, or a natural resin may be incorporated with the synthetic resin. Where greater electrical insulation is desired ground mica may be used as the filler, as in Micalex. Where heat-resistance is wanted the filler may sometimes be asbestos. It can thus be seen that a wide variety of characteristics can be expected in the final product depending upon the method of manufacture even with the same base material. The phenol-formaldehyde molding materials are marketed under such trade names as Bakelite, Durez, Durite, Catalin, and Reynolite.

The phenol resinoids may also be impregnated into paper or fabric and compressed into sheets, tubes, blocks, or rods, which are machinable and easily fabricated into many kinds of articles. These have higher tensile strength than the products molded of the powdered material. Silent gears and pinions are now largely made of the laminated molded materials. Other typical articles made of laminated phenol resinoids are fan blades, trays, electrical panels, meter cases, and drawn parts. The physical characteristics of the laminated material depends to a large extent upon the material used as filler. For smooth-surfaced hard products, such as small pinions, a fine grade of linen may be used, while for larger gears a heavy duck may be employed. One commercial material used for gears has a tensile strength of from 8,500 to 11,000 lb. per sq.in., and a compressive strength up to 40,000 lb. per sq.in. The laminated materials are sold under such trade names as Bakelite laminated, Micarta, Textolite, Celeron, and Formica. Phenol can also be employed with furfural, hexamine, or other chemicals, or the phenol can be replaced by cresol, to produce similar plastics. Furfural has the disadvantage that it makes a dark resin, but it has the advantage of low cost of the raw material and may become an important substitute for formaldehyde.

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Plastic Molding Materials
Characteristics and Uses

Urea resins. Urea will condense with formaldehyde in much the same manner as phenol to form resinoids suitable for molding into mechanical products. The urea resinoids are newer than the phenol materials, and their use has grown rapidly in the past two or three years. They are of two types, those made with urea and those with thio-urea, the latter incorporating sulphur. The chief points of difference between the urea and the phenol resins are lighter color and greater hardness. They were used first for plates and dishes because of the light translucent colors that were possible, and because of their "unbreakable" quality even with great hardness. Lately they have been used for mechanical parts where ornamental color effects are important, such as for clock cases, and they have been proposed for such uses as commercial scale frames where a pure white color is desired. In general the other mechanical and electrical characteristics are very similar to those of the phenol molding materials. One product, used widely for dishes, has a specific gravity of 1.49, and a tensile strength of 5,000 to 6,000 lb. per sq.in. Both the weight and the strength, however, will vary with the type and quality of filler employed. Typical molding materials of the urea group are Beetle, Aldur, and Unyte. The urea resins are also used for impregnating fabric and paper for making laminated molding materials for uses similar to those of the laminated phenol products.

Phthalic anhydride resins. Glycerol, commonly known as glycerin, is condensed with phthalic anhydride to form synthetic resins which are used for molding in the same manner as the phenol resins. They are known under the name of Glyptal, and are used either directly with fillers for molding various articles, or as resins for impregnating fabric or paper to make gears and other laminated products. Glyptal resins have high binding power, and they will also withstand somewhat higher temperatures than the phenol resins, or about 300 deg. C.

Other synthetic resins with varied characteristics are produced with other chemicals. Typical ones are Victron and Vinylite, which are made of styrol and of vinyl-acetate. The vinyl-acetate resin is thermoplastic, softer and clear in color, finding use where these qualities are wanted.

Casein plastics. The plastic molding material made by the action of formaldehyde on casein has been known since 1885. The casein plastics are marketed under trade names such as Erinoid, and Colasta, and they are of the thermo-plastic class. Casein plastics are furnished in sheets, rods and tubes, and are easily formed under heat and pressure. Much lower temperature and pressure than used for the thermo-setting resins will serve for molding, and they can be again and again softened by heat continued drawing or bending operations can be performed on parts of them. The casein plastics are softer and less water-resistant than the phenol and urea types, however, and are not suitable for mechanical parts where hardness and permanent form are required. The greatest usefulness of casein plastics is in the field of ornamental articles. As casein is a milk product the supply of the raw material is limited, but the plastics have found important application because of the ease of working and the susceptibility for taking beautiful coloring with dyes. They are not inflammable like the nitro-cellulose materials. Casein plastics are very good electrical insulators. The tensile strength is given as 7,600 lb. per sq.in. Unlike the phenol-formaldehyde resins, they will not withstand the action of alkalis or strong acids.

Pyroxylin plastics. These materials are available in sheets, rods, and tubes, and can be molded easily with heat and pressure in a similar manner to the casein plastics. They are composed in general of nitro-cellulose with camphor. The latter hardens the material and makes it less inflammable. Because of cold flow they are not as suitable for mechanical and electrical parts as the plastics of the thermo-setting class, but they are widely used where their fine coloration and toughness make them suitable. They are also employed for non-shattering glass. Pyroxylin plastics are marketed under trade names such as Celluloid, Amerith, and Pyralin. The material is colorless, but can be dyed to any color. The tensile strength of nitro-cellulose plastics ranges from 4,500 to 8,500 lb. per sq.in., depending upon the amount of filler, and the specific gravity is from 1.35 to 1.60. The dielectric strength is in general about the same as that of the phenol compounds.

An article descriptive of cellulose acetate plastics appeared on p. 72 of the February number of Product Engineering, and one on urea resinoids on p. 110 of the March number. Hard rubber for molding was described on p. 458 of the October, 1930, number, and an article on hard vulcanized fiber appeared in the September, 1930, number.

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